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Disentangling the fuzzy front-end: an integrative literature review

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Abstract

Within the vast body of research on new product development (NPD), the so-called 'fuzzy front end (FFE) of innovation received and continues to receive considerable attention. The importance of the FFE can hardly be underestimated as it has been widely established that improvements to this early phase of the innovation process far exceed advances in later stages of the innovation cycle (Poskela and Martinsuo, 2009; Verworn, 2009). Even though its importance cannot be mistaken, FFE research results have been widely dispersed; scholars for example still have problems to settle upon a clear definition of the term 'fuzziness' (Brun, Saetre and Gjelsvik, 2009) and different research approaches and focal points of research are used interchangeably (Reid and de Bretani, 2004). This dissertation is an attempt to understand and synthesize the 'fuzzy front end' field of research. In doing so, it attempts to answer two research questions: (1) In the FFE research field, what are the different research streams and how have they developed over time and (2) what are the empirically proven success and contingency factors related to managing the fuzzy front end successfully?

By means of an exhaustive integrative literature review, 103 publications were reviewed and close-read. The dissertation contributions to the literature in the following ways: first, a visual overview regarding the definitions on the terms 'fuzziness' and the 'front-end' is provided. Next, literature is categorized on (1) methodology type, (2) innovation dimension and (3) conceptual group. Third, success and contingency factors are identified and discussed and a tool is constructed that allows decision-makers, managers and entrepreneurs to understand how the FFE should be managed for their specific situation and context. Besides a theoretical contribution on the actual content of the FFE-literature field and the way it has developed over time, this dissertation also is of practical use for managers and entrepreneurs as it provides insights to move towards more successful FFE-processes.

Keywords: Fuzzy Front End; New Product Development; JEL-Codes: O31; 032;

Acknowledgments

A dissertation is not to be taken lightly. It is the crown on a university degree and even though it is known to be a struggle from some, for me the process was more smooth than expected.

I set out writing this dissertation rather skeptical as I am fonder of doing things that make a difference in real-life rather than writing an academic epistle. Over the course of time however, my scepsis disappeared: if one really dives deep into a subject, it is possible to gain actual deep understanding rather than just scratching the surface and this was deeply gratifying.

I am very grateful to my thesis supervisor Alexandra Xavier. She, like me, wants a dissertation to have a practical use not just for researchers but also for businesses and individuals. Alexandra, thank you for your guidance, help and kind words. Both with my dissertation and my personal life.

This dissertation also marks the end of me living in Portugal for two years. During the first 23 years of my life, when people asked me if I was happy, I always said: 'yes, but..'. The but signified the big lack in my life: finding love.

I found exactly that here in Portugal.

Ana, I consider myself truly lucky to have found you. I know we will last because it is real.

Pap, mam, for several years already, I am a grown-up man, responsible for my own choices and mistakes. Your love, care and never ending support have made me who I am. I couldn't have wished for a better youth.

Tim, my partner in crime here in Portugal. We first met in kindergarten when we were 3 and our friendship has lasted since. During the last 2 years, our bond grew even stronger. With friends like you Thijs and Maarten, I have all I could ever wish for.

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1 Introduction

Understanding how to manage the development of new products and services is vital for enterprises, both small and large, since innovative capacity nowadays, is a vital factor related to firm growth and profitability (Cho and Pucik, 2005). An important part of the process of new product development (NPD) is the fuzzy front end of innovation (FFE). FFE refers to the initial, ambiguous part of the new product development cycle and is, by its very nature, hard to manage (Khurana and Rosenthal, 1997). FFE is crucial however, for the success of innovation, since it has been shown convincingly that the potential benefits yielded from optimizing the FFE-process outweigh the potential gains in the rest of the NPD-cycle (Poskela and Martinsuo, 2009; Verworn, 2009).

Unfortunately, the literature on the fuzzy front end remains highly dispersed. Three important reason lay at the root for the field to remain highly opaque. First, scholars take very different focal points of research and as a result different scholars are attempting to tackle the same phenomenon from various angles. Second, research often is case specific and concerns for example a specific type of innovation or firm (Bocken, Farracho, Bosworth and Kemp, 2014; Herstatt and Verworn, 2004; Williams and Kochhar, 2000). Third and last, authors take – at times – contradictory points of view. One can, for example, encounter a heated debate with regards to the question whether it is possible to capture the fuzzy front end as a process. In this debate, on the one hand scholars argue in favor of so-called activity process models that map the activities involved when managing FFE (Cooper, 1988; Khurana and Rosenthal, 1997; 1998). Other scholars however, have gone as far as to argue that any attempt to structure a process that is by its very nature so fuzzy are doomed by default (Buggie, 2002; Brunswicker and Hutschek, 2010; Nobelius and Trygg, 2002).

One might rightfully call it a showcase of irony that the research field researching ‘fuzziness’ has itself become rather fuzzy. This dissertation contributes to compile, synthesize and visualize the content of 103 publications regarding the fuzzy front-end. By means of a rigorous and comprehensive integrative literature review, the goal is twofold. First, the review will help to better understand the different research streams, how they have developed over time and how they relate to each other. By specifically looking at the factors that have been proven to contribute to a successful FFE process, interesting insight can be gained for managers, decision-makers and entrepreneurs. In the past, Frishammar (2008) already made a similar attempt to map these so-called ‘success and contingency factors’. He however, only included 15 publications in his review which is rather low number as in our review 63 publications were used to provide an overview of success and contingency factors. Also, since then, seven years have passed which implies that a new overview should yield new insights.

In line with the above, this dissertation asks two research questions:

1. *In the FFE research field, what are the different research streams and how have they developed over time?*
2. *What are the empirically proven success and contingency factors related to managing the fuzzy front end successfully?*

In order to answer these two research questions, this dissertation is structured as follows: chapter two serves to outline the methodology used for our integrative literature review. Aim

here is to neatly and chronologically explain every methodological step and consideration to make re-production of this study possible. Chapter three is devoted entirely to elaborate on the definitions and concepts that are subject of research. Separate sections will be devoted to understand 'fuzziness', 'the front-end' and the main concepts related to innovation. This section will be summarized by means of a visualization; importantly, this visualization should *not* be seen as a new conceptual model. Instead, it is a way to grasp and understand the relevant dimensions related to the fuzzy front-end of innovation. In chapter four, we will identify and highlight the different research streams, the number of contributions for each stream and their evolution over time. After this chapter then, the reader will have gained a clear understanding of the FFE research field and its evolution over time.

In chapter five, all factors that have empirically been proven to effect the FFE (success and contingency factors) will be reviewed and summarized. From this chapter, two conceptual tools emerge; first, the visualization used in chapter three will be merged with new insights on success and contingency factors. This will allow us to see how success and contingency factors fit into the FFE process. Second, a tool that shows what the impact of success and contingency factors is for each specific FFE context is constructed. This tool is relevant for decision-makers, managers and entrepreneurs since it allows them to understand how to manage the FFE better. Chapter six finally is devoted entirely to conclusions and recommendations for future research. Both research questions will be answered here and additionally, elaborate recommendations for future research are provided.

2 Methodology

This section is meant to shed light on the research methodology and approach followed. The chapter is structured as follows: First, the research methodology will be explained and justified. Second, a conceptual structure of the review will help the reader to better grasp the approach followed in the remainder of the work. Third, the methods via which the review was conducted will be explained. This includes how the literature was identified, analyzed and summarized. Since the outcome of this dissertation is a new synthesis of the existing literature in the final part of this chapter, the chosen form of synthesis will be presented.

2.1 Integrative literature review: justification

As the purpose of this dissertation is to gain a better understanding of a very fragmented field of research, an *integrative literature review* is conducted. It is important to make clear that an integrative literature review is not to be confused with any ordinary literature review. An integrative literature review is a: '… form of research that reviews, critiques, and synthesizes representative literature on a topic in an integrated way such that new frameworks and perspectives on the topic are generated' (Tarraco, 2005: 356). Put differently, an integrative literature review is meant to summarize what is known about a specific topic and draw new conclusions regarding what has been proven. By doing this, new insights and conceptual frameworks can be generated and new knowledge is thus created. An ordinary literature review on the other hand, serves to understand and highlight the theoretical concepts underpinning the specific topic a researcher is addressing in his or her research. An integrative literature review is therefore much more elaborate and as such serves as a separate research methodology.

Doing an integrative literature review is justified in a two cases. First, the topic has to be either emerging or mature. Second, an integrative literature review is justified '… when contradictory evidence appears, when there is a change in a trend or direction of a phenomenon and how it is reported, and when research emerges in different fields' (Tarraco, 2005: 359). Taken the above in account, the fuzzy front-end research field qualifies for the proposed research methodology. FFE has been the subject of research roughly since the beginning of the eighties, while the term 'fuzziness' has received attention since the seventies (Duncan, 1972). The field of FFE therefore clearly is a rather mature research topic. On top of that, the FFE research field is highly dispersed and fragmented since, as we will see later, scholars tackle the topic from very different points of view and while some argue in favor for process (activity) models capturing the entire FFE process (Koen et al., 2001), other authors believe research on the FFE as a whole is preposterous (Buggie, 2002). To the best of our knowledge, no integrative literature review regarding the existing literature exists in extant literature, while the mature and highly dispersed field calls for one. Goal should be to create a: '… review, critique, and the potential reconceptualization of the expanding and more diversified knowledge base of the topics as it continues to develop' (Toracco, 2005: 357).

2.2 Integrative literature review: conceptual structure

Literature indicates that any integrative literature review should start with a coherent conceptual structure to order its findings; this can be done in a number of ways. First, one can opt for a guiding theory to serve as a conceptual structure (Wrzesniewski and Dutton, 2001).

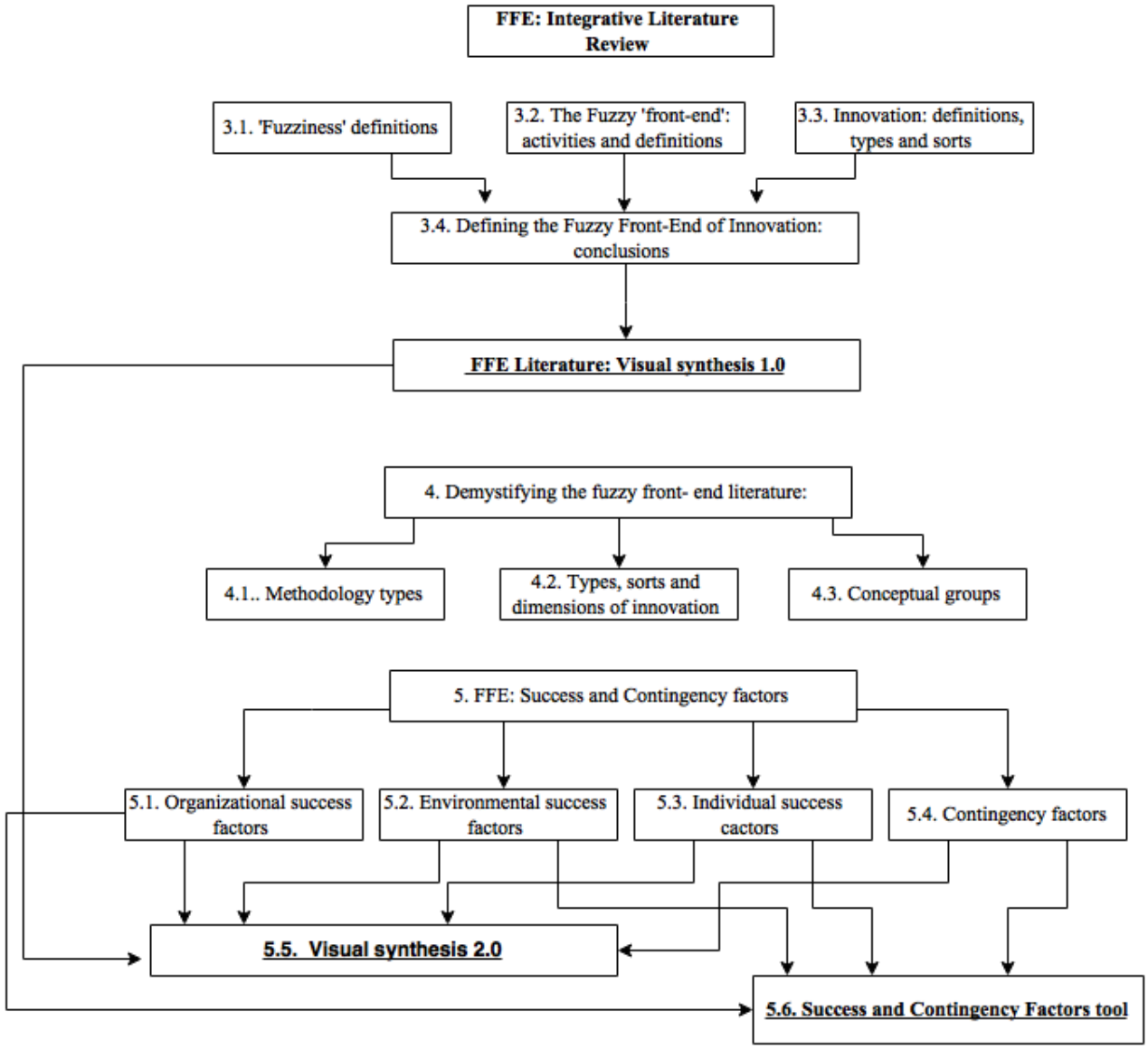
Second, one can choose a set of competing conceptual models as a means for structure (Bem, 1995). In this dissertation, the first approach is followed. Figure 1 (cf. page 6) serves to depict the conceptual structure of this dissertation

As is shown, our overview commences with an exploration of the definitions of the concepts involved (fuzziness, front-end and innovation). This generates the first output of this dissertation by means of a visual overview of the related concepts. In chapter four, we will try to elucidate general trends in literature over time and come up with a way to conceptualize all the different research streams. Chapter four does not as such generate new concepts, but does help to gain an in-depth understanding of the research field, specific topics under research and the methodologies used. As such, this chapter is highly relevant to identify research gaps. In both chapter four and five, we make use of an earlier classification by Reid and de Bretani (2004) who argue that FFE literature generally takes the approach of the individual, the environment or the organization. Thus, their framework acts as guiding theory to construct a map of the literature. In chapter five, contingency and success factors are mapped again along the dimensions of the individual, the organization and the environment. Chapter five generates two novel outputs. First, the visualization provided earlier will be merged with the identified success and contingency factors to generate an all-encompassing visualization of both the FFE process and the way success and contingency factors fit into the process. Second, a visual tool serves to help decision-makers understand which success and contingency factors are important for their specific case. With the chosen conceptual structure, we therefore have taken the requirements mentioned earlier into consideration since we have (1) generated new conceptualizations and knowledge and (2) have used an existing framework to structure our overview (Reid and de Bretani, 2004).

2.3 Integrative literature review: research design

To conduct this integrative literature review, a Scopus search was conducted. Scopus is the largest abstract and citation database of peer-reviewed literature and includes scientific journals, books and conference proceedings. It includes over 55 million records, 21.915 titles and 5000 publishers ("an eye on global research", 2015). Our Scopus search includes all scientific publications available in the database as we did not put any restrictions on the type of entry (e.g. journal, book etc.). The search conducted includes all publications between January, 1995 and March, 2015 and generated a list of 160 contributions[1]. By looking at journal title and the title of each specific paper and, when in doubt, skimming through the paper, all non-relevant entries were disregarded. Table 1 (cf. page 6) depicts the selection process and papers excluded. A substantial amount of papers was disregarded for a variety of reasons including: (1) publications without an author being mentioned, (2) publications lacking an abstract, (3) publications regarding a different topic, (4) publications with insufficient scientific rigor, (5) publications in a language other than English and (6) publications that appeared twice. Of the above, especially the number of publications regarding a different topic is noteworthy. Many of these papers either discussed a mathematical notion called 'fuzzy logic' or were contributions in the field of linguistics.

[1]Please note that only results from the 'social sciences and humanities' were included as results from 'life, health and physical sciences' do not serve the purpose of this dissertation.



Moreover, the five publications with no or insufficient scientific rigor typically were conference papers where authors argued

Figure 1: conceptual dissertation structure

in favor of a specific stance without offering substantiated evidence to support their argument. Beal (2002) for example simply discusses findings based on 'long experience at Corning'. After applying the aforementioned selection criteria, a list of 103 articles remained. This list is the basis on which the remainder of this dissertation is based.

Table 1: Publication selection process

Search Criteria	Number of publications
All scientific publications for the term 'fuzzy front end'	160
Publications with 'no author'	5
Publications with 'no abstract'	2
Publications regarding a different topic	39
Publications with no or unsufficient	7

scientific rigor/methodology	
Publications in languages other than English	3
Publications that appeared twice	1
Total number of remaining publications	103

2.4 Integrative literature review: form of synthesis

An author can choose to synthesis the literature in many ways. Naturally, the form of synthesis depends to a large extent on the nature of the literature being synthesized. Possibilities include: (1) a complete reading of each entry, (2) analyze methods and findings only and (3) a staged review (a first review of abstract followed by an in-depth review) (Tarraco, 2005). In our case, a staged review approach was followed. After applying the aforementioned selection criteria, every abstract was read to understand the type of paper, the topic under research, the type of innovation and the methodology. After that, all papers were close-read as this was a prerequisite to fully grasp the contents of the papers. Even though this approach was very laborious, it yields a few significant advantages. First, it allows one to map all literature conceptually: at times, abstract of papers do not reflect their actual content. By close-reading each entry, the actual contribution made to scientific knowledge can be verified. Additionally, we were able to clearly demarcate between papers that empirically prove a specific relation between two variables in relation to the fuzzy front end and papers that provide us with a mere theoretical contribution. Taking this approach thus allows for more in-depth insights. Naturally, close-reading all articles introduces a potential bias for the researcher. To tackle this issue, in what follows, we outline every step that was taken (chronologically) while conducting this research.

After reading the abstracts of all entries, it was clear that the FFE research field was highly dispersed and scholars were using different methodologies and approaches while concepts were often used interchangeably. To get a grip on this high diversity, initially, all literature overviews, all papers dealing with the definitions of both ‘fuzziness’ and ‘front-end’ as well as the most cited publications were close-read. From this, three observations were made. First, the number and scope of existing literature reviews was rather limited and the literature reviews that were there failed to take all publications into consideration. Additionally, frequently cited papers dated back to the nineties. Second, the most cited papers were concerned with so-called process ‘activity’ models and attempted to map the activities firms conducted during the FFE. And third, researchers did not agree on the definitions of fuzziness and the front-end. From this, chapter three (on definitions) emerged as it was necessary to thoroughly understand what it is that we were investigating.

Next, all 103 publications were classified based on their respective conceptual group. This was done by briefly summarizing each paper after close-reading each one. These summaries were synthesized into conceptual groups. Coming up with the different conceptual groups was not straightforward, it required re-reading several papers as well as a clear conceptual structure. The conceptual structure was found in a paper by Reid and de Bretani (2004) who provided a framework that allowed us to classify research based on the focal point of research (individual, organization, environment).

While close-reading all papers and classifying them into conceptual groups, two other insights were gained. First, a high number of researchers used case-studies to support their research. This number was so high that it prompted the question, what research methodologies were used across the entire research field. This was the motivation to separately look at this issue. A second observation was related to the type of innovation under research. Especially recently, researchers had started to publish on the relation between the way the FFE is managed and the type/sort/dimension of innovation of the specific project; evidence was found for example, that the way the FFE should be managed for incremental innovation is very different compared to radical innovation. This spurred the third part of chapter four where papers were classified according to innovation sort, type and/or dimension. After classifying all entries on innovation type/sort and dimension, the conclusion was drawn that chapter three (on definitions) needed another section which enabled us to understand the different forms of innovation and their interrelations.

Finally, several entries (especially recently) were using data-sets to empirically pinpoint factors (so-called success and contingency factors) that were highly important to improve the way the FFE was managed. Even though some authors previously synthesized these factors (Frishammar, 2008; Kim and Willemon, 2003), still the decision was made to focus on this in chapter five. A new overview on success and contingency factors is justified for a few reasons. First, the last attempt to list success and contingency factors was done in 2008 meaning that since then seven years of research have passed (Frishammar, 2008)[2]. Second, in his overview, Frishammar only includes fifteen articles. This number is rather small compared to the 63 publications used for chapter five. Finally, as we will see in chapter five, the presented overview of success and contingency factors differs in at least four ways to the one by Frishammar. Together, chapter three, four and five form a theoretical foundation for grasping the subject-matter, the way the subject-matter has evolved over time and its research gaps as well as a comprehensive overview of what the factors that are *empirically* proven to yield an effect are all included in the scope of this dissertation. Thus, answering directly to the research objectives proposed.

[2] Please note that the majority of publications in our sample are published after 2008.

3 Fuzzy Front end of Innovation: Definitions

This chapter is devoted to provide the reader with a sound understanding of the focal point of research of this thesis and subsequently the FFE-literature field. It should therefore be seen as a necessary prerequisite to be able to grasp the analysis conducted in the remainder of this dissertation. As the title of this chapter already indicates, FFE concerns 'fuzziness', 'the front-end' and 'innovation'. Accordingly, these three realms will mark the respective sections of this chapter. Goal is not to provide a fully comprehensive overview of each term. Instead, we seek to provide an overview of what each term is taken to mean and what the different definitions are that scholars have been advocating. Besides gaining a foundation to grasp the remainder of this dissertation, a visualization will be generated to visually summarize the content.

3.1 'Fuzziness': definitions

The 'fuzzy front end' (hereafter FFE) of innovation is part of the research field of new product development (hereafter NPD) and has received major attention since the late 80's. Cooper and Kleinschmidt (1986) were the first to point out that NPD-literature, until then, lacked a focus on the early phase of product development. They postulated that we might have been too preoccupied with: 'the 'big picture' – questions of strategy, synergy, orientation and selecting the right technology and market areas' (Cooper and Kleinschmidt, 1986: 72). In their study, where they investigate the actual product development *process* – from idea to product – they found that firms that win focus on the *early* phase of the new product development. Following these initial insights, Smith and Reinertsen (1991) popularized the term Fuzzy Front End (FFE). By now it is well-established that if a firm succeeds to improve the fuzzy front of innovation, the advantages supersede improvements in other parts of the innovation cycle (Poskela and Martinsuo, 2009; Verworn, 2009).

Defining the fuzzy front end of innovation is not straightforward however. It involves gaining an understanding of what 'fuzziness' means. Peculiarly, no consensus on the actual definition of fuzziness has been reached as is pointed out by Brun, Saetre and Gjelsvik: "As we have seen, several researchers have already addressed the issue of fuzziness. Their contributions, however, valuable as they are, do not really nail down what fuzziness is, though all of them seem to view it as a kind of uncertainty in a generic sense of the term, or as a problem in processing available information" (Brun et al. 2009: 64). Table 2 represents the dimensions of 'fuzziness' as they have been established in the literature and includes: (1) uncertainty, (2) equivocality (3) complexity, and (4) variability, The definitions mentioned are based on an overview by Chang, Chen and Wey (2007) and have been adapted and broadened slighted by the author.

Table 2: An account of the relevant dimensions of 'fuzziness' adapted from Chang et al (2007)

Definition	Relevant dimension	Study
The absence of information and knowledge and the lack of ability to process relevant information relating to the front-end environment, means, goals, and their causal relations.	Uncertainty	Duncan (1972) Galbraith (1973) Milliken (1987)

		Dosi and Egidi (1991) Kahn et al. (2003)
The diversity of interpretations among and the ignorance of the existence of the front-end environment, means, goals and their causal relations.	Equivocality	Axelsson (1977) Daft, Sormunen and Parks (1988) Doll and Zhang (2001)
Complexity is the range of difference in and the amount of interdependence in the front-end environment, means, goals and their causal relations	Complexity	Tatikonda and Rosenthal (2000) Kim and Willemon (2003)
The rate of change and the intensity of change in the front-end environment, means, goals, and their causal relations	Variability	Dess and Beard (1984) Dess and Keats (1987) Correa (1992)

It goes beyond the scope of this dissertation to elaborate exhaustively on the definitions of 'fuzziness' and its evolution over time. Hence, we suffice with a brief description of the four dimensions identified. It is interesting to note that all dimensions in table 2 (cf. page 10) are, to some extent, related to processing information. Brun et al. (2009) claim that: "The problem of managing the "fuzziness" of a situation can be understood as a problem of processing the available knowledge" (Brun et al., 2009: 66).

Chang et al. (2007) define **uncertainty** by using early (narrow) definitions where uncertainty is the absence of information and knowledge and '…the lack of ability to process relevant information relating to the front-end environment, means, goals, and their causal relations' (Chang et al., 2007: 472). Especially this latter point is important since it implies that simply gathering more information might not be a solution to reducing uncertainty. Definitions and characterizations given by the authors mentioned in the overview differ in nature but all recognize the lack of information as a vital factor. Moreover, all definitions take uncertainty to be caused by internal as well as external factors.

Equivocality (in relation to FFE) refers to: 'The diversity of interpretations among and the ignorance of the existence of the front-end environment, means, goals and their causal relations' (Chang et al. 2007: 473). In taking this definition, Chang et al. (2007) draw upon earlier research by Daft et al. (1988) and Doll and Zhang (2001) who argue that equivocality can be more problematic than uncertainty to solve the FFE-problem since it implies a sense of ignorance.

Complexity is 'the range of difference in and the amount of interdependence in the front-end environment, means, goals and their causal relations' (Chang et al. 2007: 473). This dimension takes into account factors such as experience, assumptions, knowledge base, values but also the interdependence between individuals and groups (Tatikonda and Rosenthal, 2000).

Variability is the rate of change and the intensity of change in the front-end environment, means, goals, and their causal relations (Chang et al. 2007). While equivocality, uncertainty and complexity are strongly related concepts, variability is clearly different as it refers to the *speed of change.* A high variability implies a high uncertainty while this does not necessarily have to be the case since it is perfectly possible for a product design team to have both full

access to information and possess the necessary knowledge and thus successfully develop a new product in a highly variable industry.

The term **fuzziness** thus seems to be related to managing and processing information. Also, fuzziness includes uncertainty, equivocality, complexity and variability. Even though these terms are related, they do not refer to the same concepts. When we speak about managing fuzziness, we speak about managing a situation where there is a lack of information or an inability to process the available information. Also, even if sufficient information or knowledge is available, the process of interpretation can lead to erroneous conclusions. Moreover, managing fuzziness means dealing with a highly complex environment where both internal and external factors play a role. Finally, a fuzzy situation is a situation that changes. The speed of change can lead to even more fuzziness even though this is not necessarily the case. An accurate FFE process should therefore take into account uncertainty, equivocality, complexity and variability and should focus on the way information is managed and processed.

3.2 The fuzzy 'front-end': activities and definitions

After we have come to understand the meaning and dimensions of 'fuzziness' and have thus covered the 'fuzzy' part of the fuzzy front end, we now turn our attention to the front end (of NPD). A clear commonality one can find in the different definitions is the fact that they all describe '…that the basic function of the early phase is at least to generate the idea and to specify the product concept' (Orawski, Krolmann, Mörtl and Lindemann, 2011: 4). Table 3 explores the definitions and activities described by scholars in the field of (activity) process models on FFE. The overview given is by no means comprehensive but does list the most important contributions.

Table 3: An account of the most prominent FFE definitions and activities

Definition of FFE	FFE activities/dimensions	Study
The process from idea generation, initial screening and preliminary evaluation to concept evaluation.	Idea generation, initial screening, preliminary evaluation, concept evaluation	Cooper (1988)
The Front end includes product strategy formulation, communication, opportunity identification and assessment, idea generation, product definition, project planning and executive reviews. It encompasses everything up to a go/no go decision.	Strategy formulation, communication, opportunity identification, project planning, executive reviews	Khurana and Rosenthal (1997, 1998)
Those activities that take place prior to the formal well-structured New Product and Process Development or Stage-Gate process	Idea genesis, idea selection, concept and technology development, opportunity identification, opportunity analysis	Koen et al. (2001)
The uncertainty of customers, technology and competition.	Customer fuzziness, technology fuzziness, competitor fuzziness	Doll and Zhang (2001)
All time and activity spent on an idea prior to the first official group meeting to discuss it	Environment, individual, organization	Reid and de Brentani (2004)

The commonality one can find in all the models is the inherit focus on activities. In his definition in 1988, Cooper thought the FFE could be managed by gathering more information. He therefore proposed a formal way of dealing with FFE and postulated the FFE to consist of several stages one should pass through sequentially. Khurana and Rosenthal (1997) re-defined Cooper's initial approach. They showed that indeed, firms follow a linear process to guide the FFE however they stressed the importance of understanding interrelations: 'Thus

understanding the interrelationship between the activities is as important as the activities themselves' (Khorana and Rosenthal, 1997: 105). Khurana and Rosenthal (1997) also added more (diverse) activities to their definition of FFE including for example strategy formulation and communication. Currently, the definition of the fuzzy front end as developed by Khurana and Rosenthal is still widely used and many scholars refers to the fuzzy front end as all time and activities up to a go/no go decision.

Koen and his team built upon these insights and proposed to change the term FFE to FEI (Front end of Innovation) as they said that: 'We strongly believe that FFE implies that this portion of the innovation process is mysterious, and this attitude often results in lack of accountability and difficulty in determining who is responsible to manage the activities in this area' (Koen et al., 2001: 46). This believe can be traced back to their definition as Koen et al. define FFE by emphasizing what it is *not.* Doll and Zhang argued that describing FFE as a process is not accurate. Instead, they propose to make a clear distinction between cause and effect: "however, most writers mingle front-end fuzziness (cause) and consequences of fuzziness: unclear team vision (effect) (Doll and Zhang, 2001: 96). According to them, all our efforts should therefore be focused on reducing uncertainty by promoting free flow of information as much as possible: "Knowledge, not necessarily people, is what needs to cross organizational boundaries (Doll and Zhang, 2001: 110). In a similar vein, Reid and de Brentani (2004) developed a new definition that is even broader, where FFE is: 'all time and activity spend on an idea prior to the first official team meeting to discuss it' (Reid and de Brentani, 2004: 5).[3] We can conclude that authors have by no means agreed on the specific activities involved in the front-end and definitions have remained rather broad. Some commonalities such as idea generation, opportunity identification, concept planning and concept evaluation are however universal.

3.3 Innovation: definitions, types and sorts

One could devote an entire contribution to the definitions, sort and types of innovation. Since this is by no means the purpose of this dissertation, this section is devoted to identify and define innovation in the context of the fuzzy front end; from scanning the literature, it became immediately clear that many authors point to the importance of considering the specific sort/type and dimensions of innovation being researched as researchers point out that different types of innovation are likely to call for a different FFE process and better understanding the role of the innovation type and sort in relation to innovation is an often mentioned research gap (Buggie, 2002; Reid and de Brentani, 2011) Hence, we found it justified to devote a separate section to understand the different types and sorts of innovation. This section therefore should not be interpreted as a full-scope theoretical outline of innovation definitions. Instead, it merely serves to grasp the remainder of this dissertation and specifically the section analyses the relationship between the FFE process and the different sorts and types of innovation. To make the necessary distinctions, the Oslo Manual (3rd ed.) was used as this is a prime reference for innovation science and policy making (OECD/Eurostat, 2005). In the

[3] It should be noted that this publication is concerned in particular with discontinuous (radical) innovation which might have altered the definition slightly. Nonetheless, this FFE definition is considered highly important in FFE literature.

Oslo Manuel four different types of innovation are distinguished[4]. Table 4 depicts these types and their definitions:

Table 4: Innovation types and their definitions

Innovation Type	Definition
Product Innovation	*The introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.* (OECD/Eurostat, 2005: 48).
Process Innovation	*The implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.* (OECD/Eurostat, 2005: 49).
Marketing Innovation	*The implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.* (OECD/Eurostat, 2005: 49).
Organisational Innovation	*The implementation of a new organizational method in the firm's business practices, workplace organization or external relations* (OECD/Eurostat, 2005: 51).

As we will see in chapter four, specific publications on product and process innovation can be found in the FFE literature. Additionally, some efforts have been made to understand the difference between product and service innovation. Publications related to marketing and organizational innovation are to the best of our knowledge, non-existent.

Besides innovation types, another important and often used characterization is based on the degree of impact a specific innovation has[5]:

Table 5: Innovation dimension(s): degree of impact

Innovation name	Dimension	Definition
Incremental Innovation	Low impact	*An existing product, service, process, organization or method whose performance has been significantly enhanced or upgraded.* (OECD/Eurostat: 1992: 32).[6]
Radical Innovation	High Impact	*An innovation that has a significant impact on a market and on the economic activity of firms in that market.* (OECD/Eurostat, 2005:58).

[4] The Oslo manual does not recognize service innovation as a separate innovation type. Instead, they opt to classify service innovation under the same header as product innovation. This does not correspond with the FFE literature, where some publications specifically concern service innovation. Therefore, a separate service innovation definition will also be provided.

[5] Please note that in earlier versions of the Oslo Manuel, the distinction between radical and incremental innovation was determined by the *degree of novelty.* In the new version however, this characterization is declared void. Many publications however still use degree of novelty as a way to define the difference between incremental and radical innovation.

[6] Please note that in the latest version of the Oslo Manuel, no definition of incremental innovation is given. As a result, the definition provided is taken from an earlier version. In this version, the conceptual name used is: *A technologically improved product.* However, a footnote reveals that technologically improved product refers to incremental innovation.

Here, we find the often used distinction between radical and incremental innovation. In earlier versions of the Oslo Manuel, the distinction between radical and incremental innovation was determined by the *degree of novelty*. In the new version however, this characterization is declared void. In the FFE-literature, we can still find many publications that use degree of novelty as the determinant for distinguishing between incremental and radical innovation. Hence, an older version of the Oslo Manual was used to find an adequate definition of incremental innovation.

Third and last, we can also observe specific publications regarding innovation sort including eco-innovation and open innovation. Since the Oslo Manuel does not provide clear-cut definitions on the sorts of innovation found in the FFE, definitions provided were taken directly from the specific FFE publication concerned.

Table 6: Eco-innovation: definition

Innovation name	Definition
Open Innovation	*An organization's deliberate commercializing (exploitation) of knowledge assets to and/or acquisition from another independent organization involving a contractual obligation for compensation in monetary or non-monetary terms* (Kutvonen and Torkkelia, 2010)

Open innovation finally, as the definition indicates, is the involvement of another independent organization in the innovation process. Like eco-innovation, open innovation is not a type of innovation nor does it pertain to *degree of impact*. Rather, the difference between open and closed innovation should be seen as a scale where every organization chooses its place either allowing more or less outside involvement in the innovation process.

From this section, we can conclude that innovation can be classified according to innovation type, degree of impact and innovation sort. As has already been mentioned, the classification provided is not sufficient to incorporate all publications related to a specific innovation sort/type/dimension. In addition to the aforementioned categories we can also find publications on (1) supplier innovation and (2) service innovation. In these publications, supplier innovation is defined as: 'supplier integration (also called supplier involvement) is the collaboration with a supplier in the NPD process.' (Wagner, 2012: 38). Some might argue that supplier innovation is a form of open innovation, however, we argue it makes sense to outlie definitions in accordance with FFE literature where it is mentioned as a separate subcategory.

Service innovation seems to be a type of innovation and intuitively one could argue for it to be mentioned in table 6. However, as said, the Oslo manual does not recognize service innovation as a separate innovation type. Instead, they opt to classify service innovation under the same header as product innovation. It seems that in the relevant FFE publications this choice is affirmed. Alam (2006) for example points out that: '… four unique characteristics – inseparability, intangibility, perishability and heterogeneity – differentiate services from goods. The NSD (New Service Development) process is however, more or less the same any NPD process' (Alam, 2006: 469). Alam does make the point though, that because of the trait of 'inseparability' (e.g. inevitable interaction between customer and service provider), involving the customer in NSD is even more important.

In this section, we have identified four different innovation types, two innovation dimensions based on degree of impact, separate definitions of eco-innovation and open innovation.

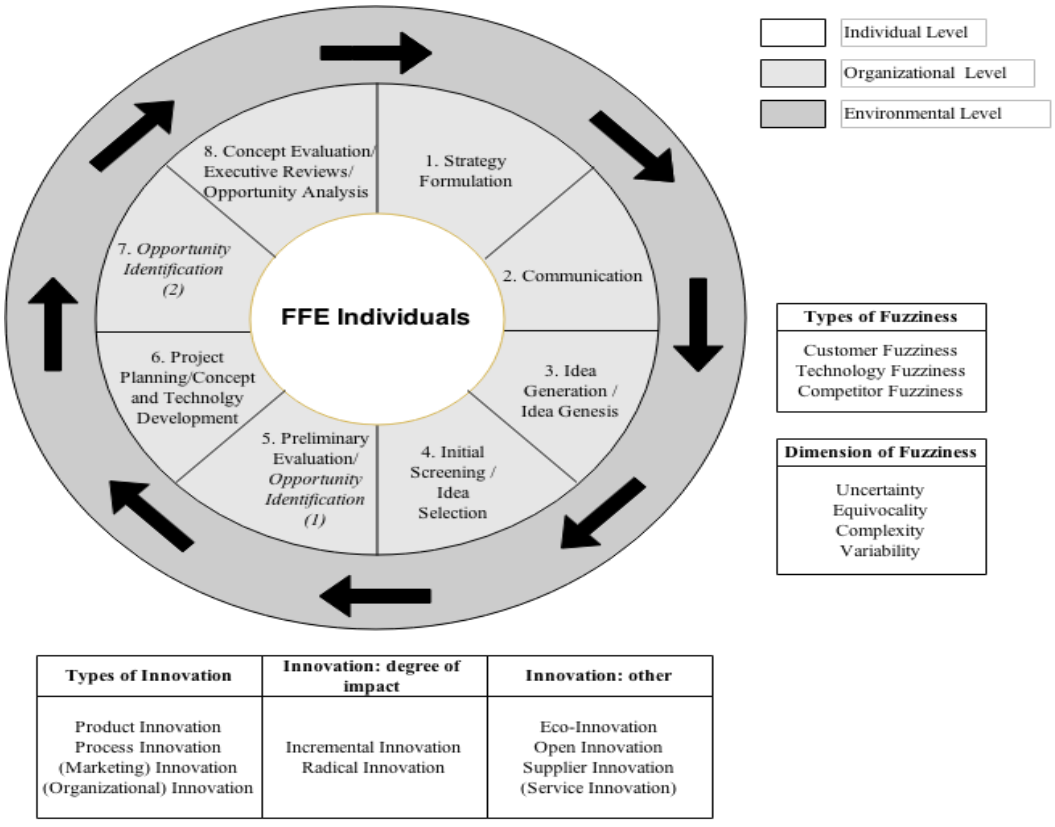
Additionally, service and supplier innovation have been mentioned separately as specific publications on both exist in the FFE research field. As stated, the concepts identified can at times overlap. It is for example, very well possible for a specific innovation to fall within the scope of product innovation, eco-innovation, open innovation simultaneously.

3.4 Defining the fuzzy Front-End of Innovation: conclusions

Clearly, authors still do not fully agree on the best 'fuzziness' and 'fuzzy front end' definitions. What we can conclude at this point however. Is that fuzziness has everything to do with managing information. Difficulties arise due to (1) uncertainty, (2) equivocality, (3) complexity and (4) variability which all have to do with the way information is processed.

Also, the idea of the front end and its associated process has changed considerably over time. Authors have slowly moved from a more formal process model to a more dynamic and contingent approach even though some commonalities can be observed. To accurately define innovation, one has to characterize innovation both on type and degree of impact. Additionally, many subcategories can be found that are not as clearly demarcated and at times overlap. Understanding these different terms and its interrelations is highly relevant since (as will be shown), the potential impact the form of innovation has on the FFE is substantial.

Figure 2 summarizes and visualizes the various views, concepts and processes as defined by the most notable scholars mentioned before. Importantly, it should not be seen as a new attempt to construct a process model.



Types of Innovation	Innovation: degree of impact	Innovation: other
Product Innovation Process Innovation (Marketing) Innovation (Organizational) Innovation	Incremental Innovation Radical Innovation	Eco-Innovation Open Innovation Supplier Innovation (Service Innovation)

Figure 2: A visual summary of the FFE process, its activities and the different types and dimensions of fuzziness involved

A few remarks serve to be able to understand the scope of figure 2 (cf. page 16). First, the choice was made to depict the FFE process in a circular way. This was done as by now, consensus exist that the FFE process should be seen as dynamic rather than linear. Next, we followed Reid and de Bretani (2004) in their distinction of the realm of the (1) individual, (2) organization and (3) environment. The eight processes mentioned are merely a merger of process defined in table 3 (cf. page 12). Several processes were taken together as they refer to the same type of activity (e.g. 'Idea Generation/Idea Genesis'). Also, 'Opportunity Identification' is shown twice; this choice was made since two authors distinctly mentioned opportunity identification but do not agree on the moment in which opportunity identification should occur, a proper visual summary of the literature could not suffice, if both perspectives were not taken into account. Additionally, all types of fuzziness and dimensions of fuzziness identified are listed. Finally and similarly, all dimensions and types of fuzziness and innovation are mentioned separately; this is a deliberate choice and is justified because they occur on all levels (individual, organization and environment) and such do not fit in a specific part of the visualization. In sum, figure 2 (cf. page 16) is a way to, at a glance, gain a comprehensive understanding of the definitions and thus the foundation of FFE research.

4 Demystifying the fuzzy front-end literature

As the meaning of the terms 'fuzziness' and 'fuzzy front end' as well as specific forms of innovation have been sufficiently established by now, focus shifts towards an in-depth analysis of the literature. As established before, literature will be analyzed in accordance with the dimensions: (1) methodology type, (2) type of innovation and (3) conceptual groups. Additionally, for all categories their evolution over time will be visualized and elaborated upon. For this purpose, our database was divided in four equal time periods of 5 years; without this fourfold division, an insightful visualization proved to be impossible due to the low number of publications in the earliest years[7]. Figure 3 serves to demonstrate this point and to gain insights regarding the total number of publications over time. Clearly, the number of publications has increased sharply as 62,5% of all contributions have been published after 2010[8]. This is hardly surprising since researchers are by now well aware of the importance of improving the FFE for the entire NPD-cycle (Poskela and Martinsuo, 2009; Verworn, 2009).

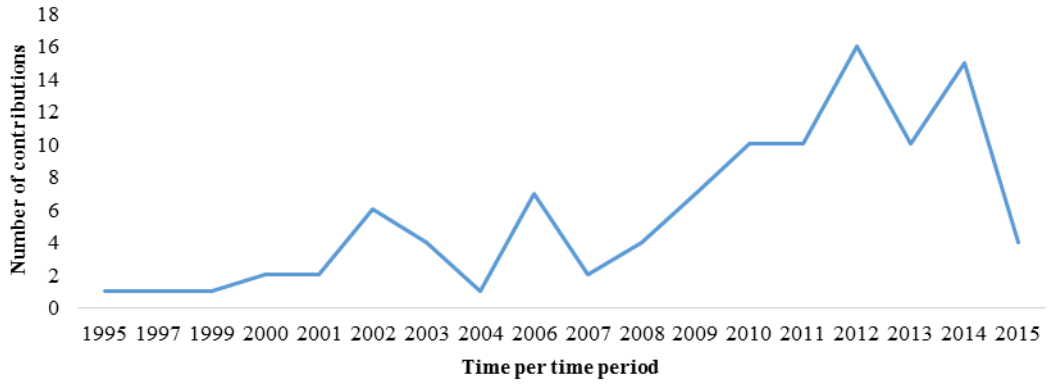


Figure 3: Total number of publications over time

4.1 FFE Literature: Methodology Types

After reading all entries in our database, a tenfold division of methodologies used by scholars emerged. Figure 4 (cf. page 19) displays the number of publications for each methodology type. When considering figure 4, a few remarks are noteworthy. First, the distinction between different methodology types was not always straightforward to make. Several studies combined different methodologies and are represented separately. Additionally, we made a deliberate distinction between publications where the data-set consisted of project data as these types of studies usually contained information regarding the success and failure of a FFE project as opposed to opinions and perspectives of individuals involved in the FFE. Third, the category 'Literature' refers to all papers that took a conceptual approach; this involves any contribution were a literature review was undertaken, a new conceptual model was constructed or researchers only made use of desk research.

[7] Please note the data was extracted in March 2015. The timeline thus runs from January 1995 to March 2015.

[8] Note that the apparent decrease in 2015 is due to the fact that the data was extracted on March 2015. The data for the year 2015 is therefore not representative.

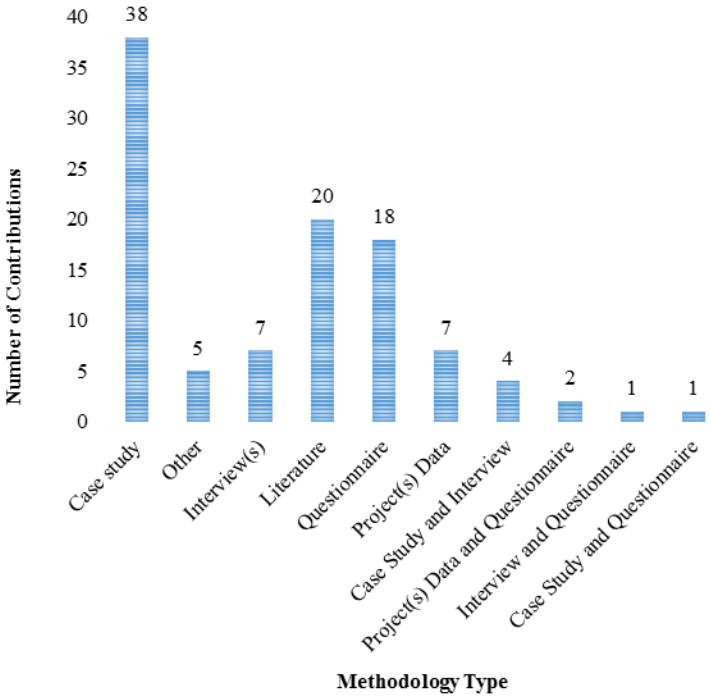


Figure 4: Number of publications for each methodology type

Fourth, the category 'Other' includes papers that take completely different approaches such as an ethnographic study (Brunswicker and Hutschek, 2010) and participatory research (Alam, 2006).

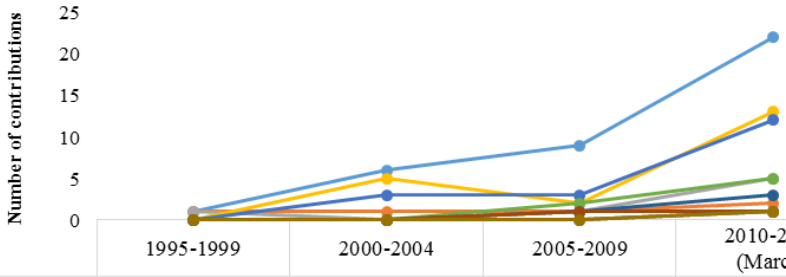
When we observe the different research methodologies identified, a few observations are immediately justified. The amount of case studies is staggering. Yin (2009) points out that a case study is specifically meant to study a contemporary phenomenon when context and phenomenon are not clearly defined. Generally, a case-study is more appropriate when the researchers asks a so-called *descriptive* or *explanatory* question ('how?'). On the other hand, the number of studies where actual (and thus not derived) project data was used is very low. This justifies a call for more research on FFE with project data (e.g. FFE outcomes).

When looking at the usage of different methodologies respectively over time, we see a similar pattern (figure 5, cf. page 20). Naturally, the absolute increase in publications as demonstrated before goes hand in hand with the increase of the most frequent methodology types (case study and literature). Besides that however, since 2005 papers with 'project data' and 'questionnaire' show a slight augmentation. One can immediately observe the low number of publications relying on first-hand project data where successful outcomes were measured (e.g. generated profit, revenue).

4.2 FFE Literature: Types, sorts and dimensions of innovation

Before we can categorize all entries for different forms, types and sorts of innovation four remarks are noteworthy: first, whenever authors specifically mentioned their paper regard a type/dimension or sort of innovation, that type was listed in our overview[9]; the authors'

[9] Please note that a few papers specifically regard a combination of two types of innovation



	1995-1999	2000-2004	2005-2009	2010-2015 (March)
Case study	1	6	9	22
Other	1	1	1	2
Interview(s)	1	0	1	5
Literature	0	5	2	13
Questionnaire	0	3	3	12
Project(s) Data	0	0	2	5
Case Study and Interview	0	0	1	3
Project(s) Data and Questionnaire	0	0	1	1
Interview and Questionnaire	0	0	0	1
Case Study and Questionnaire	0	0	0	1

Time per time period

Figure 5: Number of publications for each methodology over time

preference was therefore leading whenever possible. Second, if the type of innovation was not clear, the paper was close-read to dissect the relevant information. Often, when authors did not specify, their research concerned incremental innovation. Third, when, even after close-reading, it was impossible to elucidate the type of innovation, the entry was listed under 'Not relevant/specified'. Fourth, many papers did not regard FFE as a whole, but rather investigated a specific tool meant to aid a successful FFE. A recent example is a paper by Soukhoroukova, Spann and Skiera (2012) where they investigate the usage of so-called 'idea markets' to generate ideas. In many of these cases, the type of innovation was not relevant as the purpose of these type of publication was merely to find out to what extent the tool yielded any effect on a specific subpart of the FFE. Fifth and finally, since a specific innovation can at the same time be of a specific type, have a specific dimension and a specific sort, papers could, at times, be listed in different categories. To tackle this issue, we consistently opted to list the innovation category that was considered focal point of research by the scholar.

From figure 6 (cf. page 21), a few things can immediately be concluded. First, for most papers, the type of innovation is either not specified or not relevant. This high number is odd as scholars have repeatedly pointed out the importance of considering the type of innovation in relation to FFE (Reid and de Brentani, 2004). Many publications also consider only incremental innovation. This is understandable as the majority of innovations is incremental in nature. Another observation is related to the low number of publications regarding more specific sorts of innovation (process, service, supplier and eco-innovation). Additionally, only a few papers are devoted to the difference between open versus closed innovation and incremental versus radical innovation. Finally and as we saw earlier, the Oslo Manual mentions organizational and marketing innovation as two separate types of innovation besides product and process innovation. Both are not to be found at all in FFE literature.

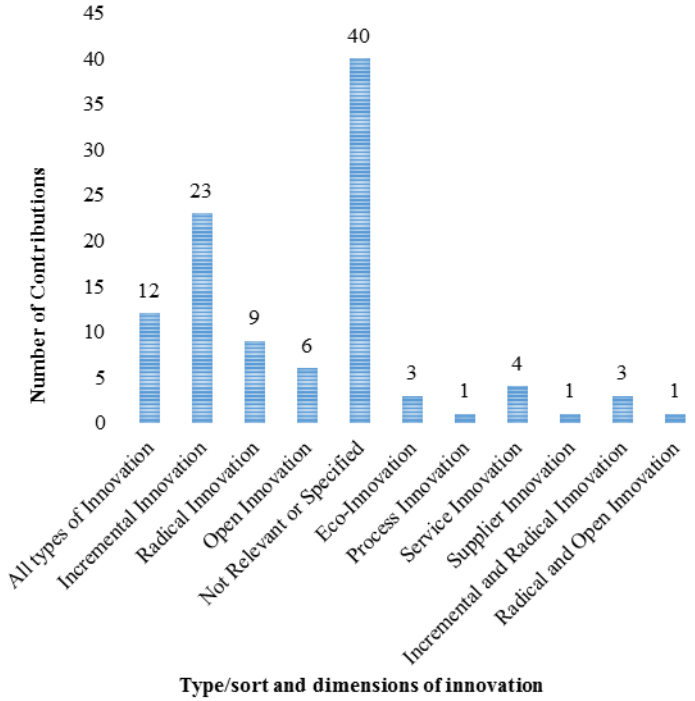
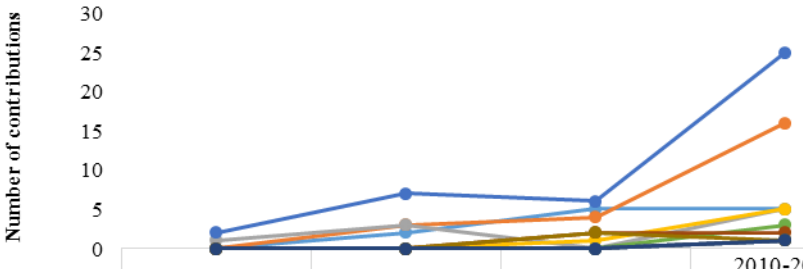


Figure 6: Number of publications for each innovation type, sort and dimension

Figure 7 depicts alterations over time and shows us a number of things. Naturally, it confirms the previous observation related to the high number of papers not specifying or not deeming the type of innovation to be relevant.



	1995-1999	2000-2004	2005-2009	2010-2015 (March)
All types of Innovation	0	2	5	5
Incremental Innovation	0	3	4	16
Radical Innovation	1	3	0	5
Open Innovation	0	0	1	5
Not Relevant/Specified	2	7	6	25
Eco-Innovation	0	0	0	3
Process Innovation	0	0	0	1
Service Innovation	0	0	2	2
Supplier Innovation	0	0	0	1
Incremental and Radical Innovation	0	0	2	1
Radical and Open Innovation	0	0	0	1

Time per time period

Figure 7: Number of publications for each type, sort and dimension of innovation over time

Second, in the last 5 years, publications specifically regarding incremental innovation have grown. The same trend can be observed for open innovation. Therefore, it seems as if gradually more research is conducted taking into specific innovation types and sorts into account. The recent increase of publications on eco and radical innovation is a testimony to this fact. It should be noted however, that the amount of papers either not specifying innovation type or not finding the type of innovation relevant is still remarkably high.

4.3 FFE Literature: Conceptual groups

As noted before, an integrative literature review is meant to generate new knowledge and insights regarding an already known field of research. This section is meant to take a first step in that respect. We started by offering our conceptual framework and the conceptual categories that emerged from our review. Next, each category will shortly be discussed. After that, we will devote some attention to look at the number of publications per conceptual group as well as the number of publications per group over time.

After close-reading all papers in our database, attempting to conceptually map the different publications was challenging to say the least; an eightfold division did however emerge. As stated, a publication by Reid and de Brentani (2004) useful to classify the categorization proposed. In their paper, they postulate that FFE literature can take the perspective of the (1) individual, (2) organization or (3) environment. Figure 8 (cf. page 23) depicts the conceptual framework.

The next short section is meant for the reader to understand each conceptual group and to clarify any methodological doubts that might arise from the conceptual framework. First, 'Defining Fuzziness' refers to the group of articles that solely aims to gain a better understanding of what fuzziness and the fuzzy front actually means. Naturally, these papers take a holistic approach and are taken to include both the environment, the organization and the individual. Second, 'Environmental Success and Contingency Factors' pertains to all articles that attempt to elucidate to what extent environmental factors induce an influence on the FFE. Publications in this group include all articles regarding the relationship between type of innovation and FFE. Also, many publications in this category demonstrate the importance of involving customers and suppliers (Alam, 2006; Brunswicker and Hutschek, 2010; Song, Lee, Lee, and Chung, 2007).

Third, 'Organizational Success and Contingency Factors' touch upon all factors within the organization that effect (both negatively and positively) the FFE. Topics include integration of departments (Moenaert, De Meyer, Souder and Deschoolmeester, 1995), managing information (Zahay, Griffin and Fredericks, 2011) and speed to market (Eling, Langerak and Griffin, 2013). The fourth category is comprised of 'Process (activity) Models'. Here, authors propose models that are meant to map the different activities undertaken during FFE. Many of the articles in this group are heavily cited and have left an important mark on the FFE literature field (Koen et al., 2001; Reid and de Brentani 2004). Often these type of articles also contributed to the definitions of the FFE. In a similar vein, organizational success and contingency factors have, at times, also been researched by these type of papers. Since the main aim of these types of paper was however to develop an activity model outlining the activities undertaken during FFE and because later, scholars have questioned the accuracy of this approach (Buggie, 2002; van der Duin, Ortt and Aarts, 2014) we felt a separate category was justified here.

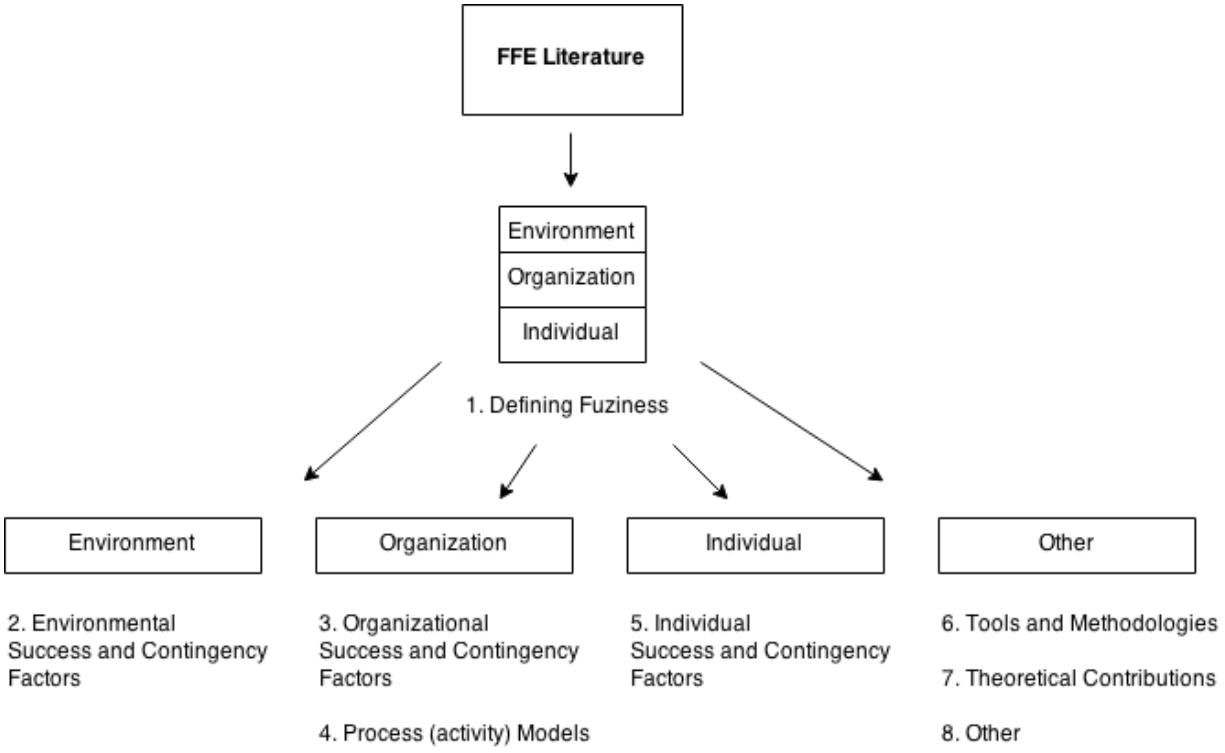


Figure 8: Conceptual framework of the different streams in literature

As a fifth category, we see several authors focus on identifying 'Individual Success and Contingency Factors'. This stream of research is relatively small but did uncover interesting insights such as the traits a leader should have (Zien and Buckler, 1997) and specific personality traits that might help for a successful FFE (Stevens and Burley, 2003).The sixth and by far most substantial category regards contributions that look at specific tools and methodologies to aid in managing FFE. Notable publications for example look at tools to involve customers online (Dahan and Hauser, 2002), ways to measure performance (Montoya-Weiss and O'Driscoll, 2000) and new tools and methodologies for brainstorming (Soukhoroukova et al., 2012). The number of tools and methodologies that have been researched however, is far more diverse than can be covered here.

The seventh category was coined 'Theoretical Contributions' and refers to all publications that develop conceptual frameworks, literature reviews and have a high theoretical nature. A well-cited example is a paper by Kim and Willemon (2003). The final category was dubbed 'Other' and contains the papers that did not fit any of the previous categories. One example is an article by Schoonmaker, Carayannis and Rau (2013) who discuss the importance of marketing as part of the FFE for TTO (Technology Transfer Offices).

Figure 9 (cf. page 24) depicts the total number of publications for each conceptual group. Clearly, focus lays on publications related to specific tools and methodologies. Also, environmental and organizational success and contingency factors play a major role in the literature. Interestingly, only a few papers contain so-called process (activity) models (models that map the FFE by looking at the activities undertaken) can be found, while these types of papers are usually very well cited. Success and contingency factors on individual level are not well studied, while literature does indicate that the traits of individuals are crucial for successful FFE outcomes (Stevens and Burley, 2003).

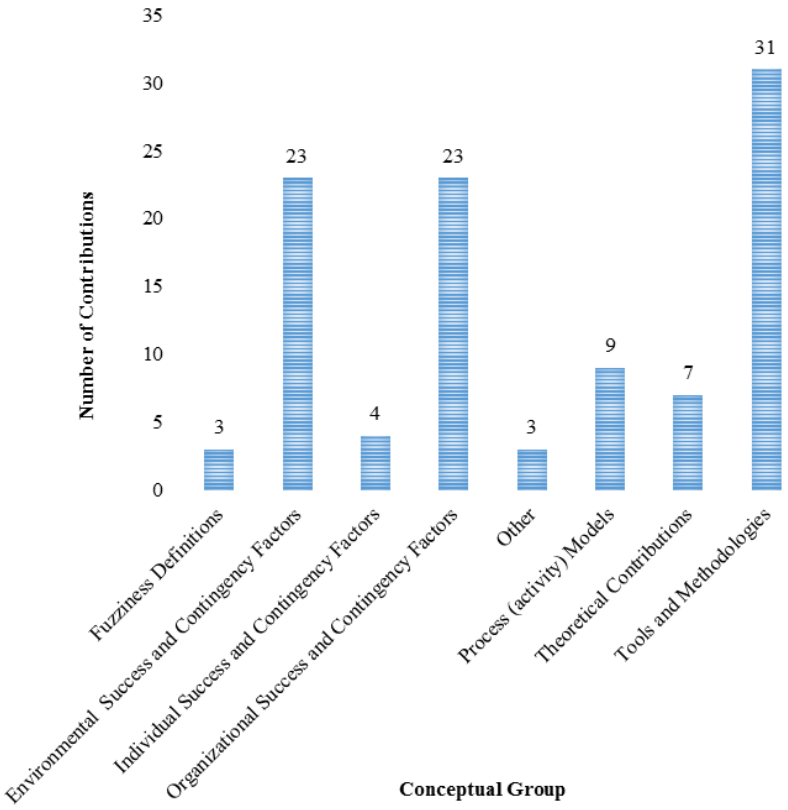
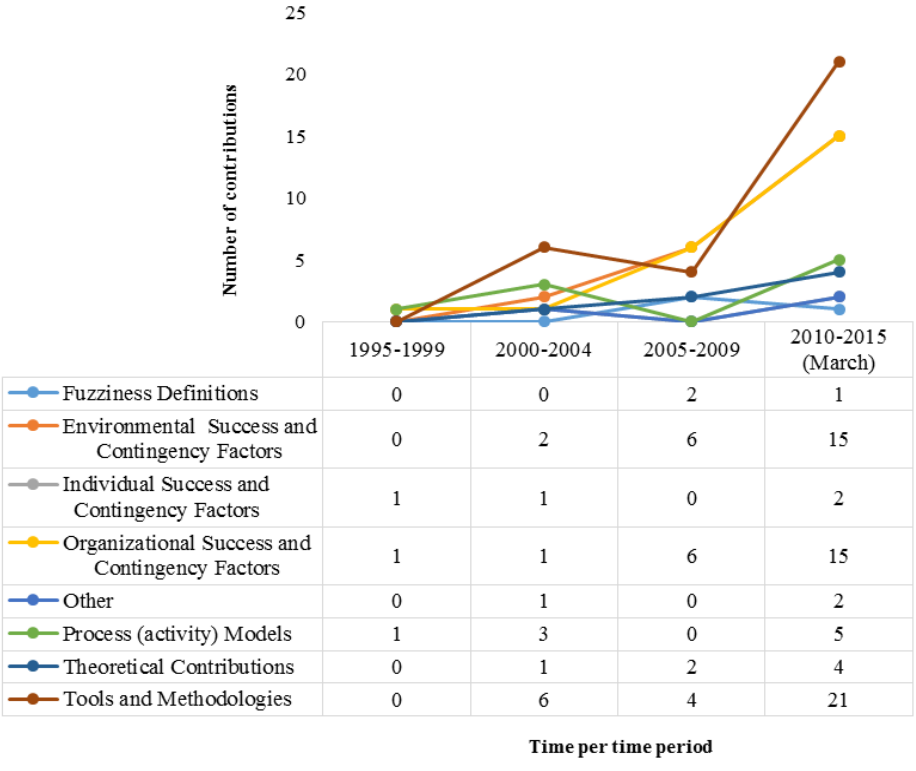


Figure 9: Number of publications for each conceptual group



	1995-1999	2000-2004	2005-2009	2010-2015 (March)
Fuzziness Definitions	0	0	2	1
Environmental Success and Contingency Factors	0	2	6	15
Individual Success and Contingency Factors	1	1	0	2
Organizational Success and Contingency Factors	1	1	6	15
Other	0	1	0	2
Process (activity) Models	1	3	0	5
Theoretical Contributions	0	1	2	4
Tools and Methodologies	0	6	4	21

Figure 10: Number of publications for each conceptual group over time

A final observation is related to the low number of articles concerning fuzziness definitions and theoretical contributions. As we saw before, scholars have been attempting to define fuzziness since the seventies and no real consensus has been reached. Perhaps, due to the extensive literature already available on this topic, many scholars choose to lay their focus differently. The low amount of theoretical contributions can be considered more striking. The high amount of diffusion within the literature field would call for exhaustive reviews, however, to the best of our knowledge, these are limited in number.

Figure 10 (cf. page 24) represents the number of publication per conceptual group over time and offers us some interesting insights with regards to how the FFE research field is developing. First, the sharp increase of publications related to tools and methodologies is noteworthy. Whereas the period 2000-2004 saw a slight decline, in the last 5 years scholars have increasingly devoted their attention this conceptual group. The steady increase of publications on organizational and environmental success and contingency factors is also manifest. Finally, relatively little contributions are of a pure theoretical nature. One can conclude at this point in time that the FFE research field is mainly comprised of publications regarding specific tools and methodologies (e.g. publications that research the effect of specific software program or other tools has on the fuzzy front-end and or methodologies to improve for example decision-making in an uncertain context) as well as publications trying to pinpoint environmental and organizational success and contingency factors.

5 FFE: Success and Contingency Factors

By now, a clear overview of the FFE research field has been sketched. Though useful for scholars, the practical use for decision-makers and managers is limited. One of the important insights from the conceptual structure proposed is that there are in fact quite a few publications that specifically try to pinpoint FFE success and contingency factors. Understanding the determinants of both success (success factors) and factors that cause significant changes in the way the FFE should be managed (contingency factors) is highly useful for managers, decision-makers and entrepreneurs as this allows them to structure their organization accordingly. This chapter is therefore aimed at providing a comprehensive overview of these factors.

As we will see, our review differs considerably from the most recent existing overviews (Frishammar, 2008) in a fourfold manner. First, Frishammar includes the success factor 'information processing other than cross-functional integration and early customer involvement' in his overview Frishammar does not however, provide his readers with arguments why he decided to mention this success factor separately. Even though the importance of adequate information processing is unquestionable, authors that address the issue of processing information are already mentioned and incorporated by other success factors such as: 'idea refinement and adequate screening of ideas, internal cooperation among functions and departments and preliminary technology assessment'. Therefore, this success factor is excluded from this overview. Second, our review includes 48 new (recent) publications that were not included in older reviews. Third, following the conceptual group identified in chapter 3, success factors have been grouped according to the previous categorization (individual, organization and environment). Fourth, in our review four success factors were added compared to Frishammar.

In this chapter, we do however build upon the review by Frishammar. In part, this is justified as Frishammar includes, at times, articles that are not present in our database because Frishammar frequently cites research dating back further then 1995. Frishammars' list of factors therefore served as baseline but has been adopted, broadened and altered based on the current integrative review. Three conceptual groups specifically concern success and contingency factors. Publications in these categories are naturally frequently used here; at times however, publications from other conceptual groups are mentioned as well. This is due to the fact that a categorization as attempted in chapter four can at times be blurry. A publication might concern a specific tool or methodology or a process model but might also still provide us with evidence regarding specific success or contingency factor. Only publications where claims are underpinned with *empirical* evidence are included in the overview. This includes any publications that makes use of interviews, questionnaires and project data. In the next sections, for every group, a table serves to summarize the success factors found after which every factor and the evidence will shortly be highlighted. Importantly, every success and contingency factors has been numbered. These numbers will be used later to visualize the information gathered.

Contingency factors are listed separately and are not grouped according to the dimensions mentioned (individual, organization, environment). This choice was made partly because the number of contingency factors is too low to make such a division useful. Also, contingency

factors typically cannot be controlled and therefore necessarily all fall in the 'environment' category.

5.1 Organizational success factors

Table 7 depicts the organizational success factors and their related studies that have strong empirical support. The number of organizational factors listed by far exceeds the other categories. This was to be expected due to the fact that most researchers thus far focused on organizational success factors. Compared to the overview by Frishammar (2008), fifteen new publications were added. Also, the organizational factor: '(Innovation) Information System' is new in the overview.

Table 7: Organizational success factors and relevant studies

Organizational Success Factors	Relevant Studies
1. Idea refinement and adequate screening of ideas	Conway and McGuiness, 1986; Cooper and Kleinschmidt, 1987; Cooper, 1988; Murphy and Kumar, 1996; 1997; Khurana and Rosenthal, 1997; Zien and Buckler, 1997; McAdam and Leonar, 2004; Boeddrich, 2004; Griffiths-Hemans and Grover, 2006; Bröring, Cloutier and Leker, 2006; Rosenthal and Capper, 2006; Verworn, 2006; Elmquist and Segrestin, 2007
2. Adequate degree of formalization	Khurana and Rosenthal, 1997; Khurana and Rosenthal, 1997;1998; De Bretani, 2001; Boeddrich, 2004; Herstatt, Stockstrom, Verworn, and Nagahira, 2006; Song et al., 2007; Verworn, Herstatt and Nagahira, 2008; Verworn, 2009; Jorgensen, Bergenholtz, Goduscheit and Rasmussen, 2011; Ho and Tsai, 2011; Schweitzer and Garbiel, 2012; Im, Montoya and Workman, 2013
3. (Innovation) Information System	Zahay et al., 2011; De Bretani and Reid, 2012; Boly, Morel and Camargo, 2012
4. Internal cooperation among functions and departments	Conway and McGuinnes, 1986; Bacon, Beckman, Mowery and Wilson 1994; Murmann, 1994; Moenaert et al., 1995; Verganti, 1997; Zien and Buckler, 1997; Heller, 2000; McAdam and Leonard, 2004; Gassmann, Sandmeier and Wecht, 2006; Kohn, 2006; Verworn, 2006; Verworn, 2009; McNally, Akdeniz, Calantone, 2011; Schweitzer and Gabriel, 2012; Wiessmeier, Thoma and Senn, 2012
5. Senior management involvement	Murphy and Kumar, 1997; Zien and Buckler, 1997; Khurana and Rosenthal, 1998; Koen et al., 2001; McAdam and Leonard, 2004
6. Preliminary technology assessment	Cooper and Kleinschmidt, 1987; Cooper, 1988; Murmann, 1994; Bacon et al., 1994; Verworn, 2006; Verworn et al., 2008; Verworn, 2009; Liu and Su, 2014
7. Alignment between NPD and strategy	Bacon et al., 1994; Khurana and Rosenthal, 1997; 1998; Ho and Tsai, 2011
8. Early and well-defined product definition	Cooper and Kleinschmidt, 1987; Cooper, 1988; Bacon et al., 1994; Montoya-Weiss and Calantone, 1994; Song and Parry, 1996; Dickinson and Wilby, 1997; Khurana and Rosenthal, 1997; Montoya-Weiss and O'Driscoll, 2000; Herstatt et al., 2006; Kohn, 2006; Backman, Börjesson and Setterberg, 2007; Seidel, 2007

9.	The presence of idea visionaries or product champions	Conway and McGuiness, 1986; Grant, 1995; Heller, 2000; Griffiths-Hemans and Grover, 2006

Idea refinement and adequate screening of ideas

The idea that it is essential for firms to have a process in place where ideas are assessed and screened, already dates back to Cooper (1988). Generating and selecting ideas is therefore an activity that lays at the core of successful FFE management (Elmquist and Segrestin, 2007). Contrary to the intuitive belief that idea refinement is an activity marked by reducing uncertainty, Kohn (2005) actually established that in this early phase of the FFE, scanning opportunities should be done based on creativity and exploration rather than a more rational (risk-averse) approach. In this light, Rosenthal and Capper's research (2006) is interesting as they argue for more ethnographic research where the behavior of consumers is observed and new opportunities are discovered as a result. Also, Conway and McGuiness (1986) found that a system to generate ideas might help in the idea refinement stage. In addition to all the above, the stage of idea refinement can be aided by making use of previous knowledge of internal personnel (Elmquist and Segrestin, 2007; Murphy and Khumar, 1996).

Once ideas have been refined, adequate screening is vital as idea screening has the highest correlation with new product performance (Cooper and Kleinschmidt, 1987). In general, two screening methods have been widely researched: business analysis and feasibility analysis. Business analysis is meant to assess to what extent an idea can be translated into an opportunity with potential for financial profitability, whereas a feasibility analysis refers to an assessment to what extent a firm can support the development with (internal) resources. Murphy and Kumar (1997) have shown that firms consider business analysis as the most important activity of the two. Literature is however ambivalent with regards to the *amount* of formalization the idea screening phase should contain. Too early and rigorous screening might cause one to disregard ideas too early (Conway and McGuiness, 1986) and for radical innovation, traditional screening might not be the best way forward as firms will inevitably lack skills or resources to carry an innovation forward and one could thus say that some extent of irrationality is necessary (Elmquist and Segrestin, 2007).

Adequate degree of formalization

Literature shows that some degree of formalization serves the FFE process well. Khurana and Rosenthal (1998) most notably make this point as they define formality as something that is: '… explicit, widely known, and characterized by clear decision-making responsibilities and specific performance metrics' (Khurana and Rosenthal, 1998: 67) According to them, formalization can help to reduce uncertainty in the FFE process. In 2001, de Brentani made a similar claim specifically for incremental innovation as she showed that successful firms usually had a formal process in place where all steps of FFE were taken subsequently (de Brentani, 2001). Khurana and Rosenthal (1998) identify absence of formality as well as excessive reliance on formality as two major risk with regards to successfully managing FFE.

More recently, numerous scholars found convincing evidence in favor of formalization (Herstatt et al., 2006; Ho and Tsai, 2011; Im et al., 2013; Jorgensen et al., 2011; Song et al., 2007; Schweitzer and Garbiel, 2012; Verworn, 2009; Verworn et al., 2008). Herstatt et al. (2006) for example, showed that successful Japanese firms carefully plan and formalize a project. Findings by Im et al. (2013) are also interesting as they show that successful leaders ensure a form of formalization in the FFE.

(Innovation) Information system

Compared to the overview by Frishammar, this success factor has been added here. We find this justified as numerous scholars point to the specific use of an (innovation) information system to accurately manage the information flow (Boly et al., 2012; De Bretani and Reid, 2012; Zahay et al., 2011). Intuitively, these findings seem to correspond with the different dimensions of 'fuzziness' as defined earlier since these dimensions indicate that manage fuzziness implies managing an (uncertain) information flow. Zahay et al. (2011) show that the information flow during the FFE is so complex that the challenge of managing this properly is even more substantial than previously theorized. De Bretani and Reid (2012) confirm these findings and show that specifically for discontinuous (radical) innovation, a sophisticated information system can yield great advantages. Finally then, Boly et al. (2012), make an interesting contribution when they show the usage of 'innovative accounting' (metrics designed to measure innovative performance). This latter findings is in accordance with recent highly popular startup literature (Blank, 2005; Ries, 2011).

Internal cooperation among functions and departments

Sufficient cooperation between all layers of an organization also has a significant effect on the FFE process (Moenaert et al., 1995; Kohn, 2006; Verganti, 1997; Verworn, 2006). McAdam and Leonard (2004), specifically point out that fostering internal cooperation can result in increased innovation efforts as well as decreased resistance to change. Naturally, cross-departmental cooperation leads to knowledge creation, up and downstream acceptance of innovative projects, reduces uncertainty and results in more synergy between strategy and NPD. Kohn (2006) found that especially the cooperation between the marketing and R&D department is of the utmost importance as these two departments are responsible for concept and product development. Other scholars found a positive effect with regards to integration between other departments as well (Bacon et al., 1994; Verganti, 1997). Importantly, Bacon et al. (1994) showed that just promoting integration between departments is not enough as trust and effective communication between different members of such cross-departmental teams is a necessary prerequisite for such teams to function properly.

Findings supporting cross-functional integration of departments have been numerous in recent times as well (McNally et al., 2011; Schweitzer and Gabriel, 2012; Verworn, 2009; Wiessmeier et al., 2012). As an example, Verworn (2009) found strong empirical support in favour of the early involvement of different departments simultaneously. In a similar vein, McNally et al. (2011), showed in a large scale study that cross-functional integration has a strong direct relationship with product profitability. Finally, results from a study by Wiessmeier et al. (2012) indicate that specifically integration between R&D departments and sales operations (key account management) is highly beneficial.

Senior management involvement

The reasons why senior management involvement is an important success factor when managing FFE are fourfold. First, it can help to overcome resistance (McAdam and Leonard, 2004). Next (and along the same lines) Zien and Buckler (1997) and Murphy and Kumar (1998) found convincing evidence that the personal involvement of so-called 'executive champions' results in a greater probability for those projects to be developed (Murphy and Kumar, 1998) Third, of high level management supports innovation right from the FFE, increased innovation levels can be observed (Koen et al., 2001). Last and as noted before, successful FFE management means cross-organizational cooperation; this is something senior management can induce and promote specifically (Khurana and Rosenthal, 1998).

Preliminary technology assessment

Naturally, this success factor has a lot to do with a technical feasibility assessment as mentioned before. Researchers agree that taking into account the technology on which a concept or idea is based, can reduce uncertainty to a significant degree (Cooper and Kleinschmidt, 1987; Murmann, 1994). The key questions of course is: what to assess? Bacon et al. (1994) noted the availability and reliability of a specific technology are important indicators when conducting a preliminary technology assessment. Verworn (2006) showed that firms are generally well aware of the importance of technology assessment as usually the technical requirements were well-defined and accounted for, even before the development of a specific project. Verworn (2008; 2009) later confirmed her own results in several studies. Liu and Su (2014) also found similar proof.

Alignment between NPD and strategy

Another seemingly logical but often overlooked factor is the coherence between the (general) business strategy of a firm and its FFE efforts. Khurana and Rosenthal (1998) showed that a successful integration of strategy and NPD means to find the right overlap between business strategy, product strategy and product-specific decisions. Naturally, no blueprint for what this overlap entails exists. Clearly however, it is important to understand one's core competencies (Bacon et al., 1994) both in the technological and business realm. Khurana and Rosenthal (1997) showed that it is hard to accurately balance between these three factors (business strategy, product strategy, NPD) as only a small number of firms in their sample demonstrated a well-defined product strategy. Ho and Tsai (2011) studied Taiwanese high-tech firms and substantiated earlier findings.

Early and well defined product definition

Scholars have argued and found evidence for the importance of an early and accurate product definition (Cooper, 1988; Cooper and Kleinschmidt, 1987; Song and Parry, 1996). Even though definitions of the concept 'product definition' vary, generally, a product definition is taken to consist of '… a form of technology plus a statement of customer benefits' (Frishammar, 2008: 23). An early and clear product definition allows for an assessment to what extent a given idea is *feasible* and to what extent it creates *value* for potential customers. Bacon et al. (1994) provide us with evidence that a good product definition can only be obtained when all departments in a firm are involved (again re-stating the importance of internal cooperation within a firm). Having settled upon a product definition, does not mean however, that the product definition is no longer subject to changes. No, instead, a firm should be open to change its definition based on relevant inputs (such as new market needs). Bacon et al. (1994) further show that such alterations should not be taken lightly and hasty change usually does not work. A careful process where a possible new product definition is carefully considered is therefore advisable. Additionally, Seidel (2007) argued that changes in product definitions can lead to ambiguity, a slower decision-making process and lower market results.

A careful distinction between incremental and radical innovation should be made with regards to the issue of establishing a product definition since it was found that both customers and firm employees are more likely to react favorably on a product definition where elements of the product are known (Goldenberg, Lehmann and Mazursky, 2001; Griffiths-Hemans and Grover, 2006). Or, as Frishammar puts it: '… humans, in general, reject radical innovations and ignore minor ones as neither type fit their cognitive schemes. Hence, modest innovations based on templates tend to be more successful than trivial or radical ones' (Frishammar, 2008:

25). Finally, even though the evidence in favor of establishing a product definition is convincing, Murphy and Kumar (1997) found evidence that formulating a product definition is done to gain credibility rather than being useful as such.

The presence of idea visionaries or product champions

One could argue that the presence of idea visionaries or product champions is in fact an individual success factor since the factor itself refers to the presence of specific individuals in the FFE process. We opted however to mention it here: the role of the organization in fostering and promotion idea visionaries is crucial since these individuals can only thrive in a culture where they are championed and promoted. The notion of so-called product champions was first coined by Conway and McGuiness (1986) when they established that even though they might not be easy to find, product champions can in fact play a major role in persisting in an innovative endeavor. Heller (2000) and Griffiths-Hemans and Grover (2006) also found that product champions can help to interpret a product concept, while their authority is important to promote the project to relevant stakeholders.

5.2 Environmental success factors

Table 8: Environmental success factors and relevant studies

Environmental Success Factors	Relevant Studies
10. Early customer involvement	Cooper and Kleinschmidt, 1987; Cooper, 1988; Bacon et al., 1994; Murphy and Kumar, 1997; Zien and Buckler, 1997; Dahan and Hauser, 2002; Flint, 2002; Langerak, Hultink and Robben, 2004; Alam, 2006; Gassmann et al., 2006; Herstatt et al., 2006; Verworn, 2006; Magnusson, 2009; Schweitzer and Garbiel, 2012; Filieri, 2013; Robbins and O'Gorman, 2015
11. Connectedness	Zien and Buckler, 1997; Wagner, 2012; Stevens, 2014; Robbins and O'Gorman, 2015

Early customer involvement

The role of customer involvement in NPD has been researched extensively. The general consensus is that indeed, involving customers early in the innovation process does have a positive effect on a successful FFE. This effect has been found for product and service innovation as well as for incremental and discontinuous innovation (Alam, 2006; Cooper, 1988; Cooper and Kleinschmidt, 1987; Murphy and Kumar, 1997; Verworn, 2006; Zien and Buckler, 1997). Alam (2006) for example, found that a sufficient amount of customer interaction can lead to a shortened development cycle and a better screening and evaluation process of concepts. How to involve customers is a question to pay particular attention to in this light. Alam (2006) again, suggest that we should ask for *benefits* rather than asking *opinions* about the ultimate solution. This is interesting as customer development and lean startup methodologies that are widely used nowadays by high growth startups have a similar philosophy and have been under researched up to date. (Blank, 2005; Ries, 2011). Intuition dictates that similar findings are to be expected here.

In recent times, previous findings have been confirmed convincingly. One might even say that early customer involvement is amongst the most well-proven success factor related to the FFE. Magnusson (2009) investigated the positive role of lead users in relation to the FFE while other publications firmly confirmed the role of customer involvement as a success factor (Filieri, 2013; Robbins and O'Gorman, 2015; Schweitzer and Garbiel, 2012).

Connectedness

As we saw in chapter three, research on a topic such as open innovation is emerging. In close accordance to this, a new success factor emerged that we dubbed 'Connectedness'. Such a new success factor is justified as numerous scholars support claims that organizations that connect (both through formal and informal networks) increase the success of their FFE. Zien and Buckler (1997) for example, point to the importance of promoting a connected team and organization. Wagner (2012) showed similar results related connectedness to suppliers. Later, Stevens (2014) points towards the importance of personal networks to find appropriate solutions for problems that pop up. Robbins and O'Gorman (2015) identify connectedness as a vital factor for successful radical innovation FFE.

5.3 Individual success factors

Table 9 depicts all individual success factors and the most relevant studies. As this category is novel, all success factors mentioned are new. As one can immediately notice, the amount of studies as well as the amount of factors are very limited. This was to be expected because the amount of publications dealing with individual success factors was limited. We did however decide to include individual success factors in our overview as a separate section. This decision was made based on the convincing evidence found in several papers that, in fact, understanding traits individuals need to have is much more important than previously theorized. Several studies listed here are by now highly cited and influential. To support this claim, consider the study by Stevens and Burley (2003) who spectacularly showed that individuals with certain traits managed to generate 95 times more profit with their FFE projects than the two other groups in the study. In the same paper, specific individuals show a success rate in FFE of 97%, compared to an 11% benchmark. Finally, both speed and effectiveness increased by more than 900%.

Besides the two success factors listed in table 9, rudimentary evidence was an increase importance of individuals with the traits: "Thinking" and "Empathy" (Montonen, Eriksson, Asikainen and Lehtimaki, 2014; Stevens and Burley, 2003). Stevens and Burley for example, note that: "T" (thinking) vs "F" (feeling) makes it easier for these analysts to learn the business discipline required to rigorously test their project-related hypotheses' (Stevens and Burley, 2003: 23). In their study, thinking was deemed equally important as intuition, we opted however to only mention intuition as a success factor. This is due to the fact that no other studies could be found providing evidence for 'thinking' as an individual success factor. Future research could shed light on these and other traits to gain a better understanding of the specific individual traits one should have to engage in successful FFE.

Table 9: Individual success factors and relevant studies

Individual Success Factors	Relevant Studies
12. Intuition	Stevens and Burley, 2003; De Bretani and Reid, 2012
13. Expertise	Griffiths-Hemans and Grover, 2006; De Bretani and Reid, 2012

Intuition

In their paper, Stevens and Burley (2003) use the so-called 'Myers Briggs Type Indicator (MBTI) to determine what traits individuals who are more successful during the FFE possess. MBTI recognizes four personality types: (1) Rationals (NT's) with a preference of intuition and thinking, (2) Idealists (NF's) with a propensity for intuition and feeling, (3) Guardians whose characteristics are sensing and judging and (4) Aristans with a preference for sensing and perceiving. It was found that the 'rationals' were vastly outperforming their peers.

Naturally, intuition is an important trait related to creativity and the evidence found can therefore also been seen as an indication for in favor of creative individuals. Reid and de Bretani (2012) developed a threefold framework, where, according to them, an FFE team should consist of (1) a boundary spanner, (2) a gatekeeper and (3) a project broker, each with specific qualities and traits. Particularly for the boundary spanner, this factor is deemed important: 'The third variable proposed to impact boundary-spanning effectiveness pertains to the "individual mind" (Stacey, 2001), or "brain", of the boundary spanner. Kuhn (1962) suggests that pattern recognition sometimes referred to as "intuition" (Roos, 1996) involves both "that something is" (a perceptual element) and "what it is" (a cognitive element).' (Reid and de Bretani, 2012: 76). Since the number of publications that found empirical evidence is still limited, further research is needed to confirm or discredit current findings.

Expertise

Griffiths-Hemans and Grover (2006) indicate that individual expertise is another factor that plays a vital role in a successful FFE. In their study, they confirm the hypothesis that 'as the level of the idea originator's expertise increases, the degree of creativity of the generated idea increases' (Griffiths-Hemans and Grover, 2006: 30). Griffiths-Hemans and Grover also point to the fact that experts tend to have a breath of knowledge which: '… increases the chances of a creative idea occurring or enhances the creativity of the idea because it adds to the individual's ability to 'bisociate'' (Griffiths-Hemans and Grover, 2006: 30). Reid and de Bretani (2012) show support for the proposition that: 'authority, experience and expertise gained through formal roles in the organization lead to greater knowledge of organizational incentives, increases both the speed and quality of information sharing'. As stated before, further research on the expertise as an individual success factor is needed to make strong claims.

5.4 Contingency factors

As all success factors have been discussed, we now shift focus to understand the relevant contingency factors. The notion of contingency factors stems from contingency theory and refers to the idea that managing an organization is dependent on both the internal and external situation (Morgan, 2007). A generic approach is therefore deemed void. Contingency factors then, are factors that list these types of contextual issues. This section, we will outline the contingency factors as identified in the literature. Next, based on both contingency and success factors, a tool will be constructed with the aim to help managers and decision-makers understand what, for their specific situation, are the most important factors to take into consideration to successfully manage their FFE process.

Table 10: Contingency factors and relevant studies

Contingency Factors	Relevant Studies
Product newness	Heller, 2000; De Bretani, 2001; McAdam and Leonar, 2004; Herstatt and Verworn, 2004; Verworn, 2006; Elmquist and Segresting, 2007; Seidel, 2007; Verworn, 2009; Oliveira, Phaal, Probert, Cunha, Rozenfeld, 2011; Van der Duin et al., 2014; Robins and O'Gorman, 2015.
Type of product	Khurana and Rosenthal, 1997; Khurana and Rosenthal, 1998; McAdam and Leonard, 2004; Alam, 2006; Elmquist and Segrestin, 2007; Kurkkio, 2011
Type of customer	Bacon et al., 1994; Murphy and Kumar, 1997; Khurana and Rosenthal, 1997;
Access to relevant knowledge	Frishammar, Lichtenhaler, Kurkkio, 2012; Bröring et al., 2006; Elmquist and Segristin, 2007;

Product newness

'Product newness' refers to the distinction between incremental and radical (discontinuous) innovations. By now, it is quite well documented that the 'newness' of a product results in crucial difference for the FFE. Naturally, this is to be expected because a radical innovation will typically correspondent with a higher degree of uncertainty. Khurana and Rosenthal (1998) showed that radical FFE innovations have less stringent definitions. Reid and de Bretani (2004) extended these ideas when they showed that the search for information is usually less formalized and success depends more on individual rather than on team-effort.

Seidel (2007) finds that radical innovation incurs more challenges on the FFE team. Also, scholars find that the role of creativity and openness becomes increasingly important when product newness increases (McAdam and Leonard, 2004; De Bretani, 2001). Recently, scholars found relationships between external networking and the likelihood to find a successful radical innovation idea (Robbins and O'Gorman, 2015). Oliveira et al. (2014) attempted to identify the specific front-end attributes that should be customized to manage product newness and identified 'development activities' and 'decision-making approach'. In line with others, they argue for more flexibility, freedom and connectedness. Frishammar concludes that innovation requires different (and perhaps harder) challenges, more complex problems solving skills and a bigger role of intuition and creativity as well as more open systems (Frishammar, 2008).

Type of Product

Second, the *type of product* has a significant impact on the FFE process. As we saw before, several publications focus on specific types of product and report about the impact this has on the FFE (Khurana and Rosenthal, 1997; McAdam and Leonard, 2004; Montoya-Weiss and O'Driscoll, 2000). In the literature, we find a threefold distinction between assembled products, non-assembled products and service products (Frishammar et al., 2012).

Elmquist and Segrestin (2007) specifically pointed to the difference occurring in relation to non-assembled products. In a recent publication, Frishammar et al. (2012) addressed this issue and, based on extant literature, point out that non-assembled products differ as opposed to assembled products in at least six ways. (1) Typically, firms use raw materials as opposed to components from suppliers, (2) product plants are usually substantial in size and located in one place with a continuous product process, (3) non-assembled products are usually part of some other value chain which means there is much more interdependency, (4) product-life cycles are very long, (5) the product process is inflexible and capital intensive, (6) changes in

product concepts might induce grave difference in the production process and visa-versa. In the same publication, Frishammar et al. (2012) provides evidence for at least the following key differences for non-assembled products: (1) Their current production process sets determines (to a larger extent) the possibilities for new product concepts, (2) the type of product is typically a single-item as opposed to a modularized assembled product, (3) requirements of customers' production processes need already be taken into account, (4) analysis of raw materials, scale-up problems is necessary. Even though Frishammar does not connect his findings to success and contingency factors, one might cautiously argue that preliminary technology assessment, an early and well defined product definition and connectedness can be hypothesized to be of greater importance for non-assembled products. Further research is needed to support these claims. In addition, Alam (2006) and de Bretani (2001) published on service innovation. Alam (2006) demonstrated the added value of involving customers in service innovation and argued that customer involvement is even more important in service than in product innovation. Clearly, building physical products requires more time and financial resources. One could expect this to have effects on the FFE.

Type of Customer

Third, *type of customer* is a vital contingency factor. The importance of customer involvement has been widely agreed upon and understanding the type of customer can help to decrease the uncertainty related to the FFE-phase as it allows one to understand what type of product or service a customer would be willing to pay for, which in turn, greatly increases the likelihood of a successful FFE. Khurana and Rosenthal (1998) found that usually customer involvement was largest for consumer products and decrease sequentially for industrial and 'original equipment manufacturers (OEM's). Even though this contingency factor seems intuitive, empirical evidence is limited. Recent popular insights however also stress the difference between B2C and B2B markets for FFE (Blank, 2009; Ries, 2011). Popular techniques such as A/B testing of ideas and (online) idea experimentation point towards more customer involvement and earlier customer involvement for consumer oriented FFE. More research is needed to make strong claims regarding the above however.

Access to relevant Knowledge

Fourth and last, 'access to relevant knowledge' is identified as contingency factor by Frishammar (2008). Khurana and Rosenthal (1997) already stressed the importance of cooperation with others except customers. Also, Bröring et al (2006) have proven the importance of absorptive capacity. They showed that: '… when firms lack absorptive capacity, they either focus in areas where they can benefit from past knowledge, or they try to establish partnerships to eliminate deficiencies in market or technology knowledge' (as quoted in Frishammar, 2008: 31). In other words, whether or not firms possess specific (relevant) knowledge is likely to affect the way in which the FFE is carried out. In a similar vein, Elmquist and Segrestin (2007) argued that existing FFE models do not take into account instances in which firms develop products or service based on knowledge or capabilities they do not possess. Naturally, this contingency factor is in line with the success factor 'Connectedness' where the importance of having access to the right stakeholders was shown (Zien and Buckler, 1997; Wagner, 2012). Hence, when a firm has less access to relevant knowledge, success factors that are could increase are: connectedness, early customer involvement, (individual) expertise, and senior management involvement (to forge the right connections).

5.5 Visual Synthesis 2.0

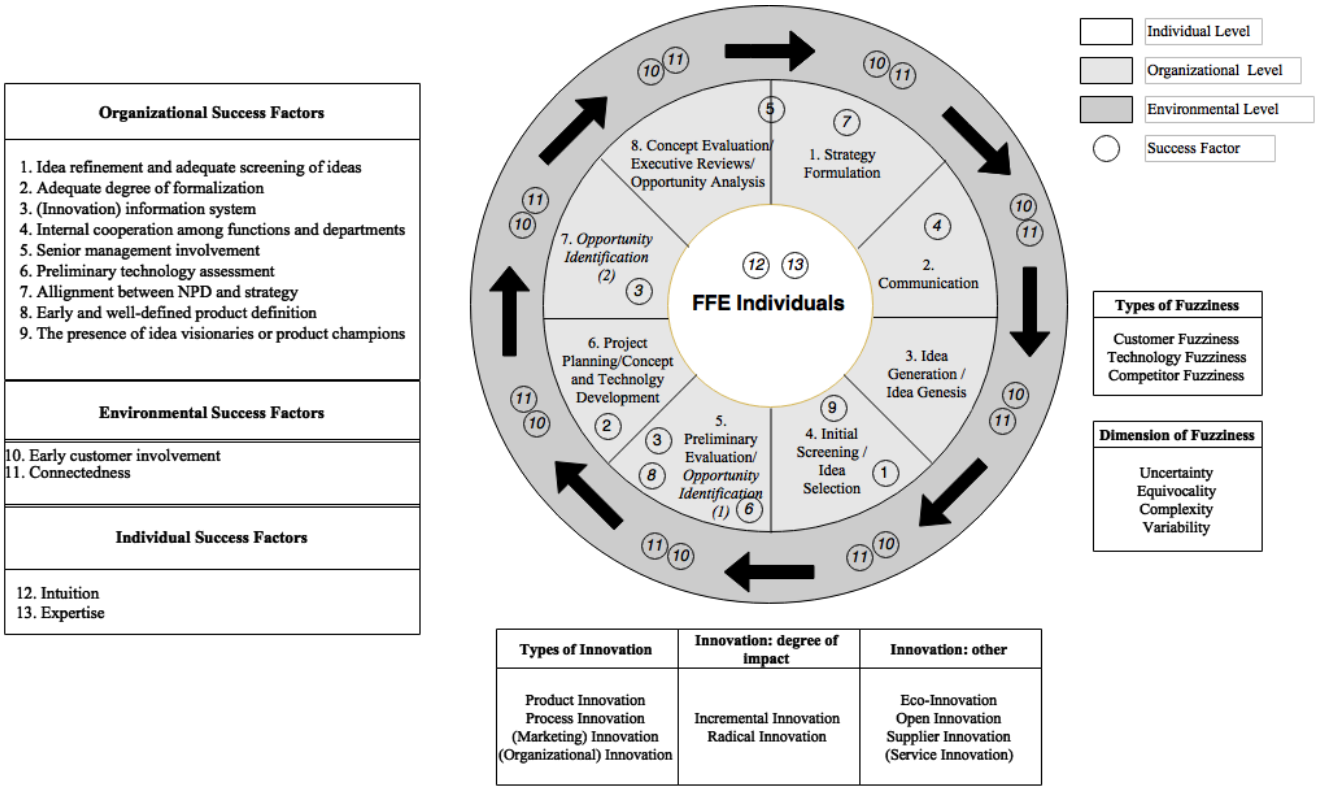


Figure 11: A visual summary of the FFE process, its activities and the different types and dimensions of fuzziness involved including the relative position of each success factor in the FFE process

Figure 11 is meant to integrate the FFE process and success and contingency factors identified. Aim is to show where each success factor is located and as such provide a visual summary of the literature thus far. Each success factor is depicted by a circular shape and each number corresponds to the numbers indicated in the relevant tables.

Figure 11 can be considered a visual synthesis of this thesis as it represents (in one view) all content analyzed. Again and as stated, figure 11 is by no means a new process model meant to depict the fuzzy front-end process; instead, it is merely a visual summary of the content one can find in the literature and depicts: (1) the fuzzy front-end process, (2) the relevant dimensions (individual, organization, environment), (3) the dimensions and types of fuzziness (and thus what it is that we are managing), (4) sorts, types and dimensions of innovation and (5) all success factors and how they fit into the process. Please note that, the specific location of each success factor was determined based on the similarities between specific activities and specific factors. No research has been conducted to determine the specific place of success factors in the FFE process. Therefore, this visualization does by no means represent new knowledge. Rather, this visualization is a starting point for discussion and further research. Undoubtedly, several success factors could be placed differently in the visualization and any empirical evidence providing proof to place success factors differently is wholeheartedly welcomed; a possible alley for future research is to confirm or refute the visualization proposed. In what follows, an elaboration on the visualization will be provided.

On a preliminary note, all success factors were positioned according to their relative realm (individual, organization, and environment). Also, no specific importance should be attributed to the specific place of a success factor within an activity since such detailed positioning

would be unwarranted. The positioning of several success factors is obvious as the actual factors relates directly to a specific activity (idea refinement and adequate screening of ideas, alignment between NPD and strategy). Also, even though no specific activities are determined for both the individual and the organizational level, individual and environmental success factors were naturally placed there.

'Adequate degree of formalization' (success factor two) is positioned in 'Project Planning/Concept and Technology Development' (activity six). Even though formalization occurs throughout the entire FFE process, activity six mostly deals with project planning and as such, one can expect formalization to be of more importance here. Also, since formalization is more important for incremental innovation (de Bretani, 2001), placing this success factor later in the process is justified as at that moment in time, more clarity exists with regards to the degree of impact/novelty of the innovation being developed (e.g. incremental vs radical).

'Innovation Information System' (success factor three) is meant to accurately manage the information flow as a result this success factor was placed under 'Preliminary evaluation/Opportunity identification' (activity five) because that is the phase during which information is synthesized to come to a decision. Internal cooperation amongst and between departments is placed in the communication-activity. It is noteworthy however, that both 'Communication' (activity 2) and 'Internal cooperation among functions and departments' (success factor four) should occur throughout the entire FFE process continuously. 'Senior management involvement' (success factor five), is positioned at the verge of 'Concept Evaluation/Executive Reviews/Opportunity Analysis' (activity eight) and 'Strategy Formulation' (activity one). We felt this was justified because senior management involvement can result in a greater probability for a specific project to be developed (end of the FFE process) *and* can increase the innovation level of an organization as such (strategy formulation) (Koen et al., 2001; Murphy and Kumar, 1998).

'Preliminary technology assessment' (success factor six) is taken to refer to some form of feasibility assessment of the technology involved to realize the idea at hand (Verworn, 2008). It should therefore be done before a project is planned and concept and technology development commences and is thus placed under activity number five 'Preliminary Evaluation/Opportunity Identification. Developing an 'Early and well-defined product definition' (success factor eight) is placed under activity five as well. Literature shows a product definition should be developed as early as possible (Song and Parry, 1997); the earliest possibility to do so is right after the idea selection/screening process.

Finally, 'The presence of idea visionaries or product champions' (success factor nine) is depicted in activity four 'Initial screening/Idea selection'. Idea champions are reported to be specifically important to promote a specific concept or idea (Griffiths-Hemans and Grover, 2006). This quality is especially important when it is not clear yet which concept/ideas will be selected to look at more specifically. One could however also argue that idea champions are of vital importance in different activities such as opportunity identification and concept evaluation since the authority of product champions is reported to be important to promote the project to relevant stakeholders (Griffiths-Hemans and Grover, 2006).

For scholars, figure 11 (cf. page 36) can aid to gain a quick and comprehensive overview the FFE overview, its main concepts, all dimensions and all success factors involved. For decision-makers and entrepreneurs, figure 11 is a tool to gain a better understanding of what the fuzzy-front end of innovation entails and what all relevant factors are to taken into

account. Section 5.6. is designed to help them even further by means of a clear tool meant to understand how the FFE processes changes for different situations and contexts.

5.6 Success and Contingency Factors tool

Figure 12 (cf. page 39) is the final deliverable of this thesis and is meant to generate a meaningful output for decision-makers and entrepreneurs. In this section, figure 12 will be explained and elaborated upon. Goal is to allow the reader to understand and apply the tool created as well its implications.

Contingency factors are depicted by squares with solid lines and represent decision-moments. The chosen order is arbitrary since determining degree of product newness, type of product, type of customer and availability of relevant knowledge might in practice be done simultaneously or in any order that seems fit for the particular process. Squares with dotted lines depict so-called 'contextual FFE categories' and show the different options that can be chosen. A separate table exhibits all success factors and their relevant numbers to quickly see what factors are effected by which situation. After going through the four respective contingency (decision) moments, 24 potential FFE situations are sketched. All squares marked by the plus-sign demonstrate success factor that have a higher importance for that specific situation. The negative-sign signals a decrease of importance. Success factors with a squared line signify an actual effect has been found in the literature. Success factor with a dotted line signify an effect can be hypothesized, but is not proven. To prove a relationship here, more research is therefore needed.

Before diving deeper into figure 12, a few remarks are noteworthy. First, all FFE categories have been taken directly from the literature. In practice however, more categories might exist. Since this dissertation is based on knowledge derived from literature, this was not taken into consideration. In a similar vein, surely one could distinguish more types of customers and products and future research could shed lights on which categories to include or exclude. Also, a deliberate choice was made to depict the success factor for which a relationship is *not* proven; this dissertation is meant to generate new concepts and ways to understand the literature, a major goal therefore is to show potential research gaps, depicting hypothesized serves this purpose. In a few cases, the same success factor is depicted to both have an increased and a decrease importance *at the same time* (one relationship is usually proven here, while the other is hypothesized) Even though this might be confusing, by displaying results in this manner, we can elucidate issues future research should be directed towards.

Importantly, the tool presented holds one major assumption namely that enterprises or FFE teams have relevant information regarding the four contingency decision-moments *while* or before they engage in the FFE process. Naturally, in some instances, this will not be the case. In cases, where enterprises engage in an innovation effort without any predefined outcome, our figure 12 will not be useful.

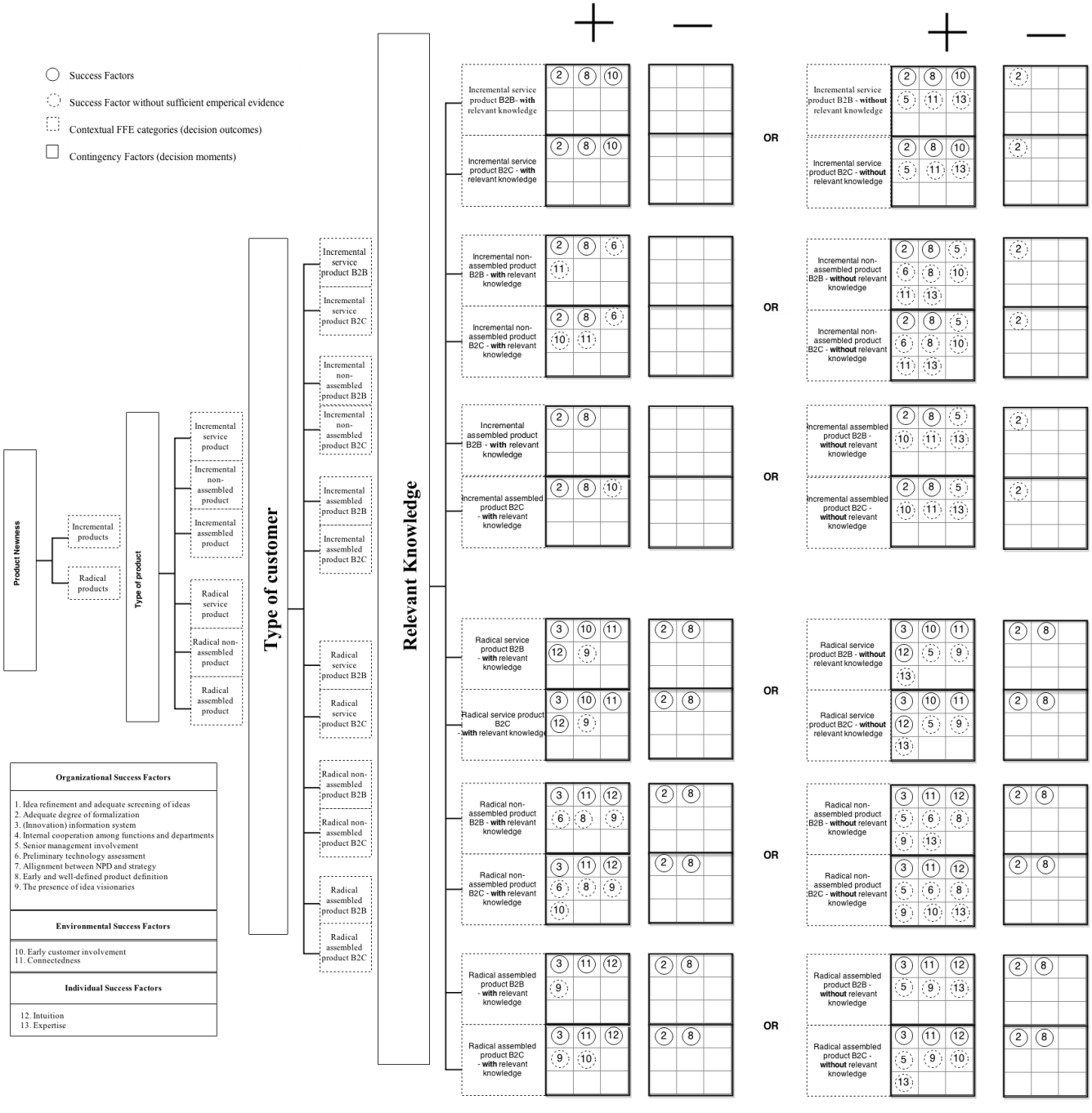


Figure 12: A visual FFE tool: relative importance of success factors per FFE situation

5.7 Success and Contingency Factors tool – insights

After these preliminary remarks have been made, we can now delve deeper into the insights figure 12 provides us with. In what follows, we will first elaborate on success factor that demonstrate a proven increased or decreased importance[10]. Next, hypothesized relationships

[10] Please note that our discussion of success factors that demonstrate a proven increased or decreased importance will be rather short. This is a deliberate choice since these effects have already been discussed earlier in this chapter and doing so again would be repetitive.

will be discussed. These relationships will naturally generate recommendations for future research which will be the closing part of this section.

For incremental innovation, we can observe an increased importance for formalization and a clearly defined product definition. This can be observed both with and without the availability of relevant knowledge. For service products – both with and without - relevant knowledge and for radical and incremental innovation- customer involvement becomes more important (Alam, 2006). For radical innovation, usage of innovative information systems, connectedness and intuition show increased importance across all situations while formalization and product definition decrease in relevancy across all situations.

Besides empirically proven effects, many relationships have simply not been researched. Based on extant literature, relationships could however be hypothesized. In this light, one could for example argued that for radical innovation the existence of idea visionaries or product champions is particularly paramount since the role of individuals to push innovation forward is essential. Frishammar et al. (2012) also provide us with indications that for non-assembled products it is more important to preliminary assess technology, define an adequate product definition and interact with external stakeholders (connectedness). Again here, more research is needed to confirm results. Also Khurana and Rosenthal (1998) give some indications that for B2C innovation, customer involvement is more important. Finally, for situations in which no relevant knowledge is available (within the firm) we argue that 'connectedness', 'customer involvement', '(individual) 'expertise' and 'senior management involvement' could all be expected to increase in significance. As we saw before, FFE is about managing information and when no relevant knowledge is available uncertainty increases. As a result, factors that increase knowledge in-flow should increase. Connectedness, customer involvement and expertise all fall in this category. Further, we argue that senior management involvement can help to forge the necessary relationships to acquire the knowledge an organization needs. Formalization should become less weighty since we have seen that when less information is available, formalization is expected to decrease.

For most hypothesized relationships, some evidence exist. In all case however, more research is needed to be able to draw any meaningful conclusion. One direction for future research could therefore be to investigate to what extent one can find an increased or decreased importance for each hypothesized relationship. Second, findings can at time be contradictory (e.g. the role of an early and well-defined product definition for radical non-assembled product B2B and B2C with and without relevant knowledge). In these cases, it would be interesting to understand how different contingency factors jointly influence a success factor. Third, at this moment, relatively little research has been conducted regarding the contingency factors 'type of customer' and 'availability of knowledge', a better understanding of the effect these components have for specific success factors would enhance our understanding of the fuzzy front-end. Figure 12 (cf. page 39) does not hold the pretention it provides clear-cut conclusion and solutions regarding the manner in which any FFE process should be managed. It can however help to understand what factors one should pay particular importance to and is a novel way to synthesize the literature

6 Conclusion

This dissertation started by emphasizing the importance of the fuzzy front-end of innovation. Indeed, improvements to the earliest phase of the innovation process have been proven to exceed advances in later stage of the innovation cycle (Poskela and Martinsuo, 2009; Verworn, 2009). Peculiarly however, to the best of our knowledge, no exhaustive (integrative) literature review synthesizing extant literature existed up to date. This is odd since understanding what we know and do know about the fuzzy front-end of innovation is of high importance for scholars to advance our comprehension on innovation generally and the FFE specifically. For practioners, understanding the FFE and more importantly, understanding how to improve the likelihood of successful FFE outcomes naturally is of the utmost importance. To understand what it is that we do and do not know about the FFE, two research questions were posed: (1) In the FFE research field, what are the different research streams and how have they developed over time and (2) what are the empirically proven success and contingency factors related to managing the fuzzy front end successfully? This concluding section is devoted to re-state the novelty of this dissertation, answer the posed research questions, highlight implications for scholars and decision-makers and to indicate directions for future research.

This dissertation ensures its novelty due to a number of reasons. First, to the best of our knowledge, a literature review of this scale has not been conducted up to date. As a result, the synthesized knowledge is likely to have more depth and breath. Second, in this dissertation, an *integrative* literature review was conducted. Such a review is specifically meant to generate new knowledge and insights regarding an already known field of research. To the best of our knowledge, no integrative literature review is to be found in extant literature. Third, existing authors frequently point to the fact that FFE literature is highly opaque. By systematically structuring existing knowledge, this dissertation contributes to reduce this dispersion. Fourth, due to a partly bibliometric approach, new insights were gained with regards to research methodologies, topics of research and types, sorts and dimensions of innovation. Fifth, the dissertation pays specific attention to synthesize the success and contingency factors that can exert an influence on the fuzzy front-end of innovation. Two comparable studies have done this in the past (Frishammar, 2008; Kim and Willemon, 2003). The most recent of these studies is seven years ago and both reviews therefore do not take into account recent publications and insights.

For practioners, entrepreneurs and decision-makers, two tools were created to aid both the understanding of and the decision-making before and during the fuzzy front-end of innovation. One tool (figure 11) (cf. page 36), allows for a comprehensive understanding of all definitions, processes and dimensions related to the fuzzy-front end of innovation. Moreover, by summarizing empirically proven success and contingency factors, the second tool (figure 12) (cf. page 39) enables practioners their FFE decision making process.

6.1 Conclusions: research questions

Chapter four was devoted to answer our first research question. Eight conceptual groups were identified and grouped according to the dimensions environment, organization and individual (Figure 8, cf. page 23). Our study found eight research streams including: (1) defining fuzziness, (2) environmental success and contingency factors, (3) organizational success and

contingency factors, (4) process (activity) models, (5) individual success and contingency factors, (6) tools and methodologies, (7) theoretical contributions and (8) other. These categories arose from close reading each entry and identifying relevant common themes. Naturally, one paper could fall in several categories. In these cases, the paper was listed under the category that best described the purpose of the researcher (e.g. if the purpose was to create a process model and success factors were identified in the process, the paper will be listed under category four).

Scholars mainly published in the category tools and methodologies (31 publications), organizational success and contingency factors (23 publications) and environmental success and contingency factors (23 publications). Fuzziness definitions (3 publications), individual success factors (3 publications), other (3 publications) and process activity models (9 publications) are relatively underrepresented. This is especially peculiar for process activity models since publications falling in this category are very well-cited.

To understand how the different research streams have developed over time, the total time period was divided into four time boxes. With 42.7% of total publications, clearly, most entries have been published between 2010 and 2015 which showcases the research field is emerging. The first time box (1995-1999) contains only three publications and as a result, no meaningful conclusions can be drawn. The second time box (2000-2004) counts fifteen publications with a strong majority (40%) for publications on tools and methodologies. The third time box (2005-2009) consists of twenty publications. Here, publications shifted towards a stronger focus on success and contingency factors (environmental and organizational). In the last time box (2011-2015), this trend continued with a primary focus on environmental and organizational success factors as well as tools and methodologies.

At this point in time, several meaningful conclusions can be drawn. First, the FFE research field is indeed dispersed since eight different research streams were identified. Second, attention for FFE research has picked up recently and scholars started publishing notably more during the last five years. Third, gradually scholars started focusing more on research related to tools and methodologies and success factors (environmental and organizational).

The second research question of this dissertation was meant to pinpoint the factors that play a role to increase or decrease the likelihood of a successful FFE process. In total, thirteen success factors and four contingency factors were found (see Table 7 (cf. page 27), table 8 (cf. page 31) and table 9 (cf. page 32). Findings were synthesized visually in figure 12 (cf. page 39). Compared to earlier attempts to summarize success and contingency factors, four new success factors have been added: (Innovation) Information system, connectedness, intuition and expertise. For existing factors, in many cases new evidence was found. The success factor ‘information processing other than cross-functional integration and early customer involvement’ was excluded in our overview. The fuzzy front-end of innovation is at its roots about managing information, every success factor therefore pertains to managing information in some form or manner, we therefore opted to exclude this success factor. Additionally, factors have been grouped on either individual, organizational or environmental level. By (visually) synthesizing what we know and do know in relation to the fuzzy front-end, this dissertation aids to push the research field forward in directions that are most meaningful. The final section of this dissertation will therefore consist of an elaborate list of recommendations for future research.

6.2 Recommendations for future research – the FFE research field

Providing recommendations for future research is an important part of this dissertation as it is one of the outputs we set out to generate. To provide the reader with a comprehensive and clear overview, recommendations will be given per research question. Table 11 summarizes recommendations related to chapter four.

Table 11: recommendations for future research (based on chapter four)

Recommendations for future research	Type of recommendation
- More publications using actual project data (with performance outcome indicators)	Research methodology
- FFE in relation to marketing innovation - FFE in relation to organizational innovation - The effect of open and closed innovation on the FFE - FFE in relation to supplier innovation (1 publication to date) - FFE in relation to process innovation (1 publications to date) - FFE in relation to eco-innovation (3 publications to date)	Innovation dimension, type and sort
- Traits of individuals in relation to the FFE	Conceptual group (content)

Important insights can be derived for scholars and researchers regarding all three categories (methodology, innovation type/sort and conceptual group). Regarding the research methodology used, the number of publications an actual project data (at times with outcome indicators) is very low. Future research specifically relying on directly derived outcome indicators would therefore be highly beneficial to advance the FFE research field.

For the relation between FFE research and type/sort and dimension(s) of innovation a few observations were also made. First and foremost, the number of papers not indicating the type of innovation under investigation was striking. More so, since scholars themselves have repeatedly pointed towards the importance of considering type/sport and dimension(s) of innovation (Reid & de Bretani, 2011). One possible explanation might be that as the FFE is the earliest part of the innovation cycle and thus primarily concerned with generating ideas; it might be the case that it is not always known what sort of innovation a firm or FFE team is attempting to engage in. However, even if this explanation were to be true, it would still be beneficial for scholars to mention innovation type, sort and/or dimension(s) whenever possible. Additionally, terms are sometimes used interchangeably, which in turn, does not contribute to the clarity of the field. No publications can be found that tackle all four types of innovation as mentioned by the Oslo Manual (product, process, marketing and organizational). This then is an interesting future direction for research. Additionally, very little publications exist that tackle issues such as eco-innovation, service innovation and supplier innovation. Is it for example, the case that the FFE process alters when firms attempt to engage in marketing or organizational innovation? Also, relatively few studies have attempted to contrast different innovation types, sort and dimensions in relation to the FFE.

When analyzing the actual content of the fuzzy front-end research field, one can immediately notice the high number of publications related to tools and methodologies. Even though these publications can yield interesting insights, they usually look at the effect a specific tool has in a specific FFE process. As a result, many publications in this field do not generate a substantial amount of knowledge for the FFE research field as a whole. The number of publications dealing with so-called process activity models (mapping the entire FFE process)

is low in number, but usually papers in this category belong to the most cited ones in the field. In recent times however, scholars are attempting to generate knowledge related to the specific factors that play a role in a successful FFE process (hence the high number of publications on organizational and environmental success factors). A substantial and largely unexplored area is the field looking into individual success and contingency factors: the little publications that exist provide us with sufficient evidence that the traits of an individual can be of high importance for a successful FFE process (De Bretani and Reid, 2012; Stevens and Burley, 2003). Besides gaining more understanding of the individual (character) traits that aid a successful FFE process, another interesting angle of research would be to see if, for different types of FFE projects (e.g. types, sorts and dimensions of innovation), different (character) traits are required. In sum, one can conclude that even though the FFE field exist roughly since the eighties, a lot of knowledge gaps remain to be filled.

6.3 Recommendations for future research – Success and Contingency Factors

Chapter five provides us with several indications and recommendations for future research. First, table 12 is meant to summarize recommendations based on the hypothesized relationship one can find in figure 12 (cf. page 39). Importantly, these relationships are already based on rudimentary evidence (usually one publication) but nonetheless deserve more attention to be able to make stronger claims.

Table 12: recommendations for future research (based on chapter five) – with rudimentary evidence

Recommendations for future research	Succces / Contingency Factor	Expected relationship (+/-)
- Rigorousness of the screening process for different FFE contexts	Idea refinement and screening of ideas	?
- Relation between formalization and FFE in the case of incremental innovation and when no relevant knowledge is available with the firm	Adequate degree of formalization	-
- Relation between senior management involvement and FFE when no relevant knowledge is available within the firm	Senior management involvement	+
- Relation between preliminary technology assessment and FFE for non-assembled products	Preliminary Technology Assessment	+
- Relation between an early and well-defined product definition and FFE for non-assembled products	Early and well-defined product definition	+
- Relation between the presence of idea visionaries and the FFE for radical innovation	The presence of idea visionaries or product champions	+
- Relation between early customer involvement and FFE in the case of incremental and B2C innovation - Relation between early customer involvement and FFE when no relevant knowledge is available with the firm	Early customer involvement	+
- Relation between degree of connectedness and FFE for non-assembled products - Relation between degree of connectedness and FFE in the case of incremental innovation and when no relevant knowledge is available within the firm	Connectedness	+
- Relation between (individual) expertise and FFE when no relevant knowledge is available within the firm	Expertise	+

Since all indications for future research given in table 12 (cf. page 43) have already been discussed in chapter five it is excessive and repetitive to discuss each recommendation in depth. We refer the reader to figure 12 (cf. page 39) and the corresponding section for a detailed account of the hypothesized relations listed and the rudimentary evidence found in the research field to support table 12.

Chapter five also gives us indications for areas that are under researched in a more general sense. First, while conducting this integrative literature review, it was striking to find out that even though recently more attention has been attributed to pinpointing the factors that contribute to a more successful FFE outcomes, no consensus is reached (yet) regarding performance measures (project outcome data). As we saw, researchers utilize very different methodologies and very rarely use FFE performance outcomes for their research. A first (more general) recommendation therefore entails the development and use of FFE performance outcomes with the aim of reaching a consensus on how to measure successful FFE outcomes.

Second, and as we have seen, relative little publications have dealt with the traits individuals should possess to increase the likelihood of successful FFE outcomes. The few publications one can encounter provide strong evidence in favor of this type of research as the effects found are substantial. Third, research has focused (especially recently) on pinpointing FFE success factors, while the contingency factors remain under researched.

An important recommendation for future research therefore should be to broaden current knowledge regarding contingency factors. The current factors ('Product Newness', 'Type of Product', 'Type of Customer', 'Relevant Knowledge') for example do not take into account the effect the type, sort and dimension of innovation can have on the FFE process since product newness only regards incremental and radical innovation. Moreover, for type of product, differences have been found for assembled, non-assembled and service product (Frishammar, 2012), however these findings should be confirmed or refuted by future research to make stronger claims. For type of customer, evidence for differences between B2C and B2B customers exist, but is still embryonic. Perhaps there are for example, vital differences in the FFE when the client is a SMB (small or medium sized business) as opposed to a large firm. With regards to the existence of relevant knowledge within the firm, a possible direction for future research would be to try to find out to what extent knowledge from outside can be acquired and or outsourced. One could imagine that the existence of relevant knowledge is especially important at FFE phase to assess whether an idea is feasible or not, which would imply that obtaining relevant knowledge from outside the firm is particularly troublesome. More generally, perhaps important contingency factors not identified at this point in time, could be revealed by future research.

Fourth and last, table 12 (cf. page 43) only mentions success factors with some evidence for a hypothesized relationship. Even when such evidence does not exist, future research could shed light on potential ways in which several success factors influence the FFE. Is there for example a relationship between 'idea refinement and screening' and the type of customer or the existence of relevant knowledge available within the firm or, in a similar vein, should the FFE process be formalized more for a B2B oriented FFE compared to B2C driven FFE? The indications for future research are ample since for every success factor, its relationship with other success factor as well as with contingency factors are still under researched. It is our hope that with this dissertation, a first outset has been given to explore these and the many of the uncharted pathways of the fuzzy front-end research field.

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